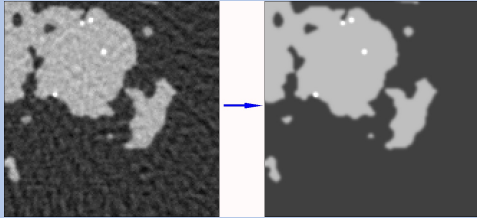# Overview of the DL-sparse-view CT Grand Challenge

Organizers: Emil Sidky and Xiaochuan Pan
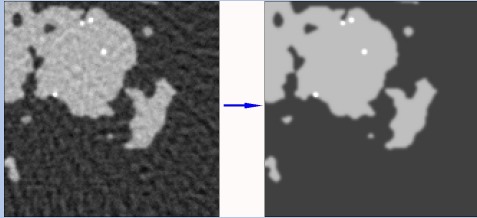
The AAPM Working Group on Grand Challenges

Motivation

Claims in the literature that deep-learning can solve
inverse problems
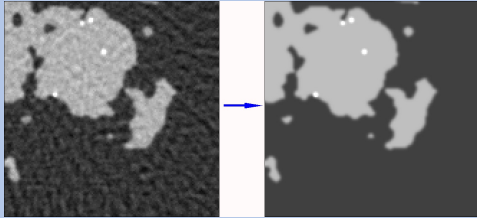relevant to CT image reconstruction

Motivation

Do CNNs Solve the CT Inverse Problem?

Emil Y. Sidky, *Member, IEEE*, Iris Lorente, Jovan G. Brankov, *Senior Member, IEEE*, and Xiaochuan Pan, *Fellow, IEEE*

arXiv:2005.10755

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Motivation

- Breast CT simulation
- Computerized breast phantom 512x512
- Adipose and fibro-glandular tissue with random structure
- 128-view ideal noiseless projections over 360 degrees, circular parallel-beam

- Deep learning recon using CNNs
- Training/validation data: 4000 phantoms and corresponding sinograms
- U-net post-processing approach: FBP followed by U-net

Solution is known to be possible with constrained TV-minimization
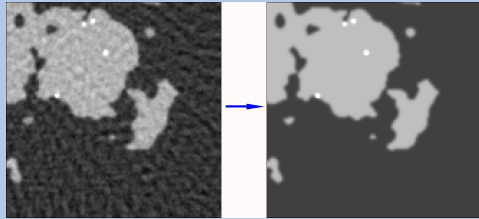
Motivation

FBP 128	CNN prediction	CNN diff.
[0.174,0.253]	[0.174,0.253]	[-0.002,0.002]
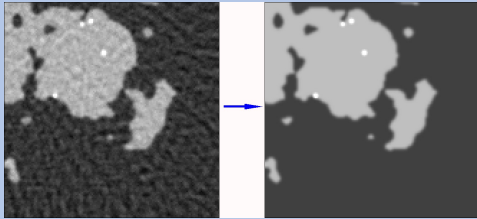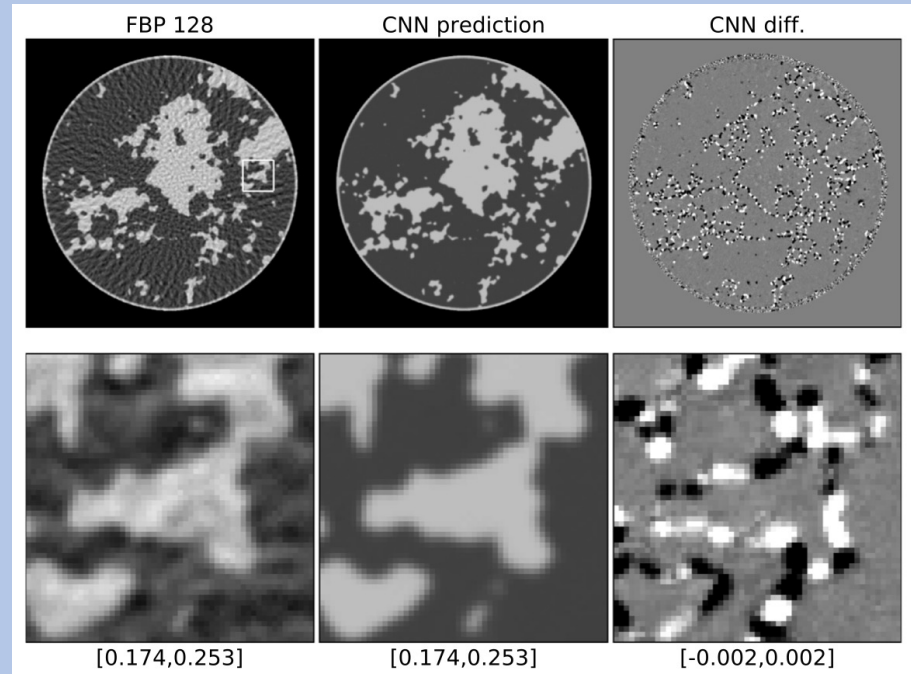
Root mean square error (RMSE): 6.76 x 10^(-4)

DL-sparse-view CT: phantom
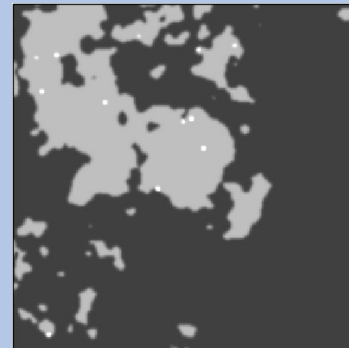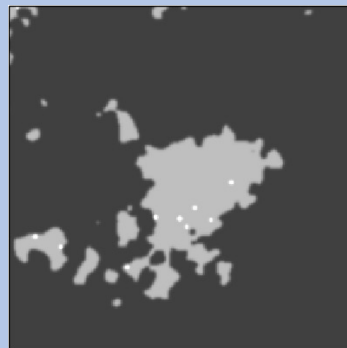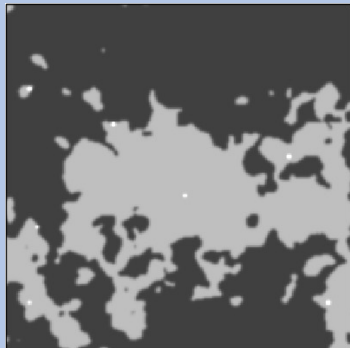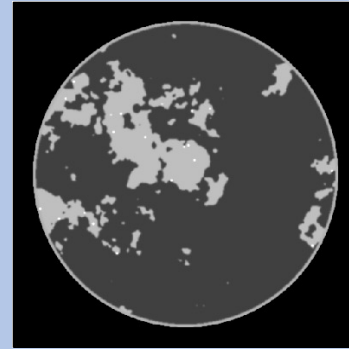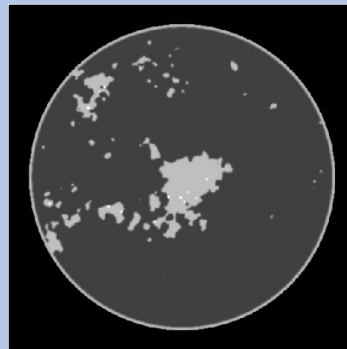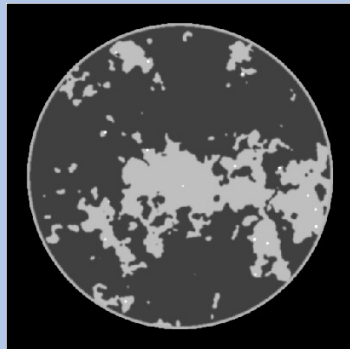
DL-sparse-view CT: training data
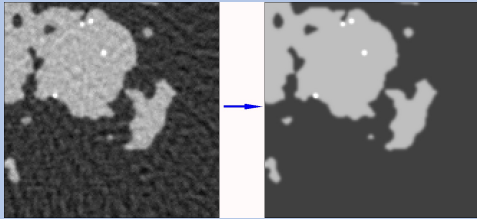
128 view

fan-beam
sinogram
unknown
geometric
parameters
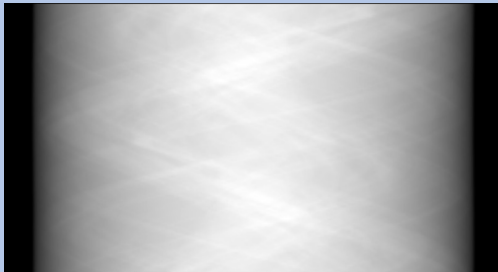
true image

FBP image
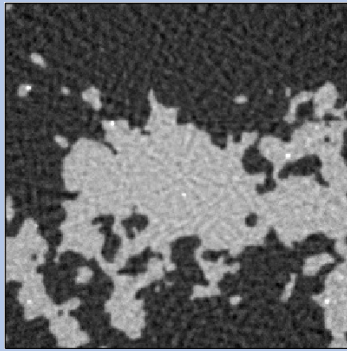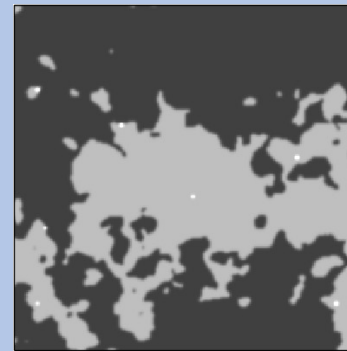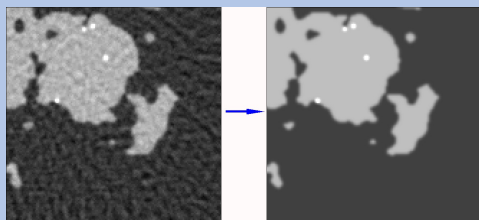
DL-sparse-view CT: platform and schedule

MedICI
Medical Imaging Challenge Infrastructure
www.medici-challenges.org

Schedule
March 17: release of training – 4000 datasets, known truth
March 31: validation phase – 10 datasets, unknown truth
May 17:   testing phase – 100 datasets, unknown truth
June 1:   challenge end

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DL-sparse-view CT: scoring

Ranking by average RMSE

Tie-breaker:
Worst-case region of interest (ROI) RMSE
ROI is 25x25 pixels

DL-sparse-view CT: validation leaderboard

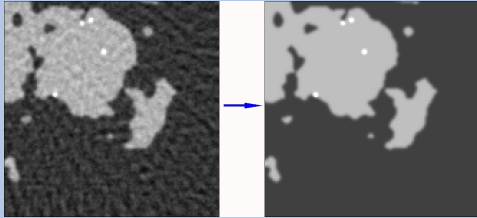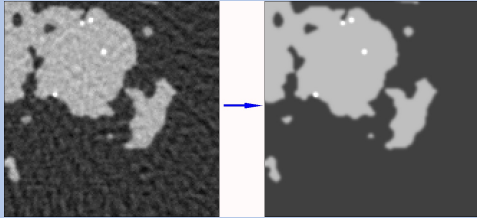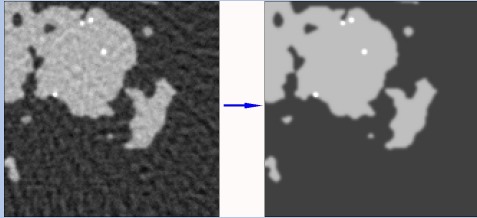| #	User	Entries	Date of Last Entry	Team Name	RMSE ▲	WC_ROI-RMSE ▲
1	**Haimiao**	35	05/15/21	HBB	0.00018191 (1)	0.00096270 (1)
2	**deepx**	9	05/16/21		0.00019372 (2)	0.00148116 (2)
3	**Max**	26	05/14/21	robust-and-stable	0.00021279 (3)	0.00157996 (3)
4	bbbbbbzhou	14	05/16/21		0.00025955 (4)	0.00170135 (4)
5	yume	6	05/14/21	list	0.00029907 (5)	0.00188446 (5)
6	Zhuoran	3	04/15/21		0.00033378 (6)	0.00213593 (12)
7	muge_du	36	04/17/21		0.00036314 (7)	0.00206619 (7)
8	CongcongDu	11	04/23/21		0.00036528 (8)	0.00213262 (11)
9	FanXiaoHong	13	04/22/21	XTU Victory	0.00037207 (9)	0.00220369 (13)
10	jabber	8	05/04/21		0.00037969 (10)	0.00207267 (8)
11	Gaoyu	9	05/13/21	YImager	0.00038189 (11)	0.00205326 (6)
12	cw	2	04/06/21		0.00041391 (12)	0.00211989 (10)
13	arpodgor	25	04/08/21		0.00044477 (13)	0.00211878 (9)
14	Jiping	38	04/20/21	SUPER	0.00047245 (14)	0.00235953 (15)
15	cebel67	3	04/07/21	DEEP_UL	0.00049916 (15)	0.00235885 (14)
16	adenker	13	04/10/21	Ill-posed	0.00057036 (16)	0.00307389 (20)
17	stke9	7	03/31/21	tldr	0.00058722 (17)	0.00292784 (18)
18	Essam	6	04/12/21	(^_^)	0.00059776 (18)	0.00299908 (19)
19	Olsalo	11	05/11/21		0.00063802 (19)	0.00281959 (17)
20	yangdidixu	11	05/08/21		0.00064448 (20)	0.00279105 (16)

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DL-sparse-view CT: test leaderboard

#	User	Entries	Date of Last Entry	Team Name	RMSE ▲	WC_ROI-RMSE ▲
1	Max	3	05/31/21	robust-and-stable	0.00000637 (1)	0.00011112 (1)
2	TUM	4	05/31/21	YM & RH	0.00003989 (2)	0.00069451 (2)
3	cebel67	4	05/31/21	DEEP_UL	0.00012923 (3)	0.00139614 (4)
4	deepx	3	05/31/21		0.00015935 (4)	0.00171093 (5)
5	Haimiao	4	05/29/21	HBB	0.00018119 (5)	0.00124403 (3)
6	HKim	2	05/31/21	MIR	0.00026678 (6)	0.00213912 (8)
7	luke199629	5	05/31/21		0.00028064 (7)	0.00187904 (6)
8	yume	3	05/26/21	list	0.00029180 (8)	0.00209860 (7)
9	Zhuoran	4	05/31/21		0.00032674 (9)	0.00272278 (14)
10	FanXiaoHong	1	05/30/21	XTU Victory	0.00036074 (10)	0.00248925 (9)
11	CongcongDu	9	05/31/21		0.00036560 (11)	0.00249880 (10)
12	jabber	2	05/31/21		0.00036881 (12)	0.00274070 (15)
13	Gaoyu	2	05/31/21	YImager	0.00037774 (13)	0.00259753 (13)
14	sinkinen	3	05/31/21		0.00040432 (14)	0.00259457 (12)
15	huyuhuster	3	05/31/21	deep-ihep	0.00045986 (15)	0.00250771 (11)
16	Loblue	1	05/31/21	NMIL	0.00051440 (16)	0.00304781 (18)
17	HDSP	3	05/31/21		0.00052114 (17)	0.00279461 (16)
18	YuliangHuang	1	05/31/21		0.00053756 (18)	0.00311100 (20)
19	adenker	1	05/26/21	Ill-posed	0.00057000 (19)	0.00291204 (17)
20	Olsalo	2	05/24/21		0.00063304 (20)	0.00309160 (19)
21	yangdidixu	3	05/31/21		0.00063831 (21)	0.00314655 (21)

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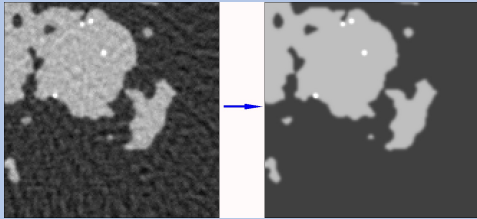
DL-sparse-view CT: top five

USERNAME	TEAM NAME	MEMBERS	INSTITUTIONS(S)	RMSE SCORE
Max	Robust-and-stable	Martin Genzel Jan Macdonald Maximillian März	Utrecht University Technical University of Berlin	6.37×10^{-6}
TUM	YM & RH	Youssef Mansour Reinhard Heckel	Technical University of Munich Rice University	3.99×10^{-5}
cebel67	DEEP_UL	Cédric Bélanger Maxence Larose Leonardo Di Schiavi Trotta Rémy Bédard Daniel Gourdeau	Université Laval	1.29×10^{-4}
deepx		Yading Yuan	Icahn School of Medicine at Mount Sinai	1.59×10^{-4}
Haimiao	HBB	Haimiao Zhang Bin Dong Baodong Liu	Beijing Information Science and Technology University Peking University Chinese Academy of Sciences	1.81×10^{-4}

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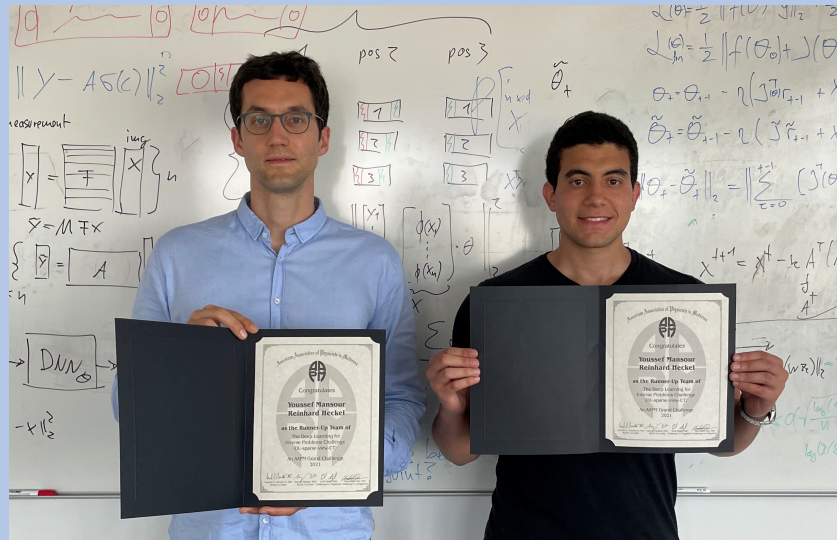
www.aapm.org/GrandChallenge/DL-sparse-view-CT/winners.asp
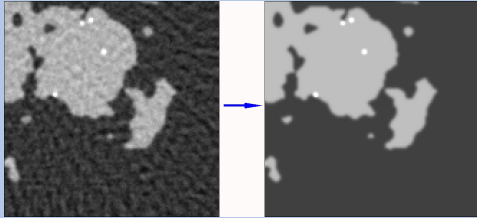
DL-sparse-view CT: runner up team

Reinhard Heckel   Youssef Mansour

Team:
YM & RH

Institution:
Technical
University of
Munich

RMSE: 3.989 x 10^{-5}
Worst case ROI RMSE: 6.945 x 10^{-4}
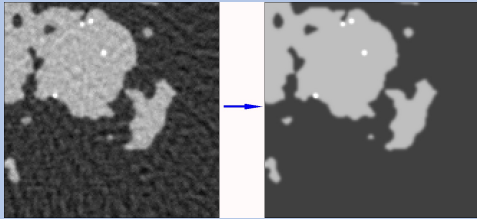
DL-sparse-view CT: winning team

Martin Genzel **Jan Macdonald** **Maximillian Maerz**

Team:
Robust and Stable

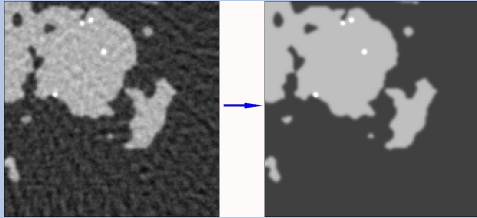Institution:
Technical
University of
Berlin

Utrecht
University

RMSE: 6.37×10^{-6}
Worst case ROI RMSE: 1.111×10^{-4}

Acknowledgments

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