
ÉTS
Le génie pour l'industrie
École de technologie supérieure

Artificial Intelligence in medical imaging

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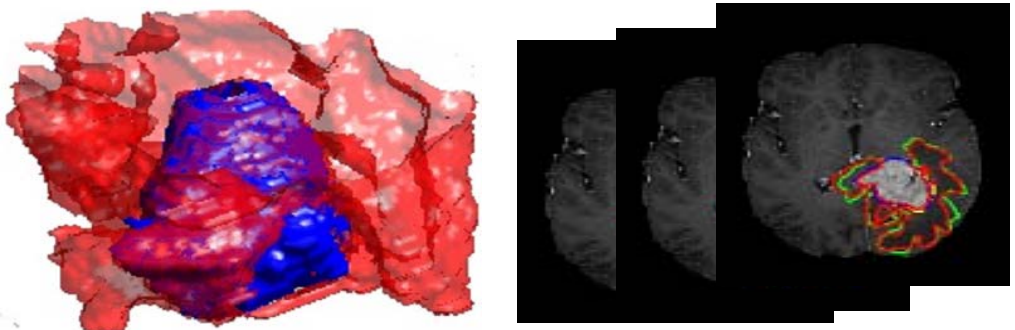
May 2018

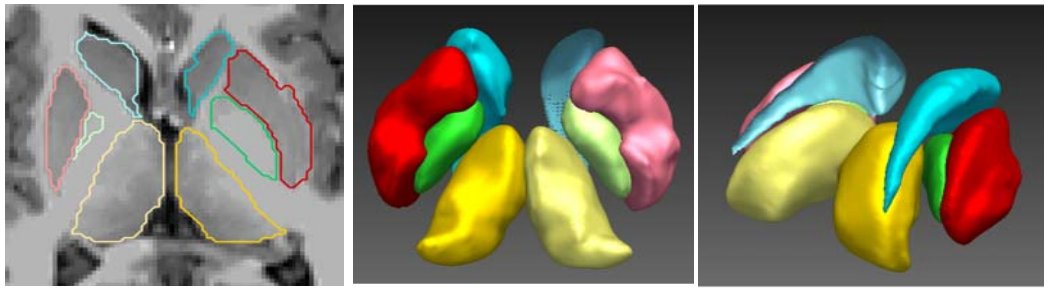
Semantic segmentation

In medical imaging: Finding organs/abnormalities

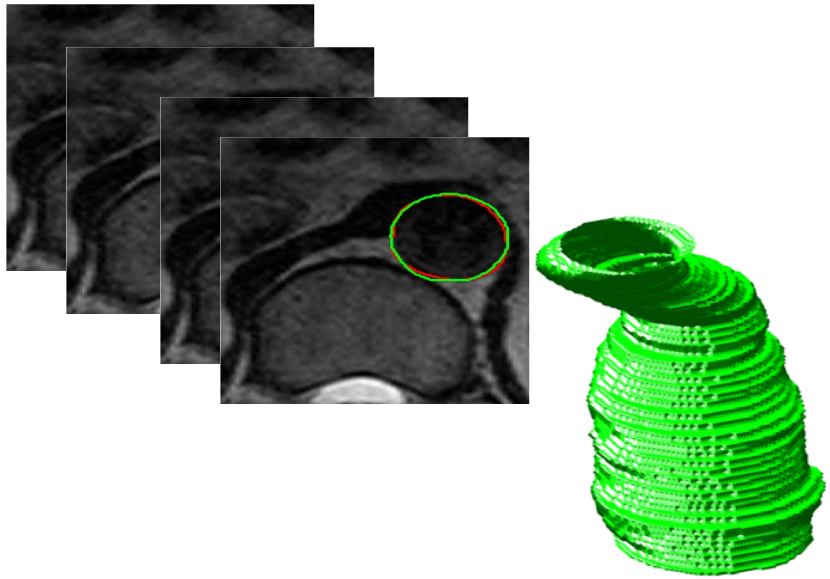
Understanding diseases, predicting their progression, evaluating treatment outcomes, incidental findings, etc.



Brain tumours
(Njeh et al., CMIG 2015)

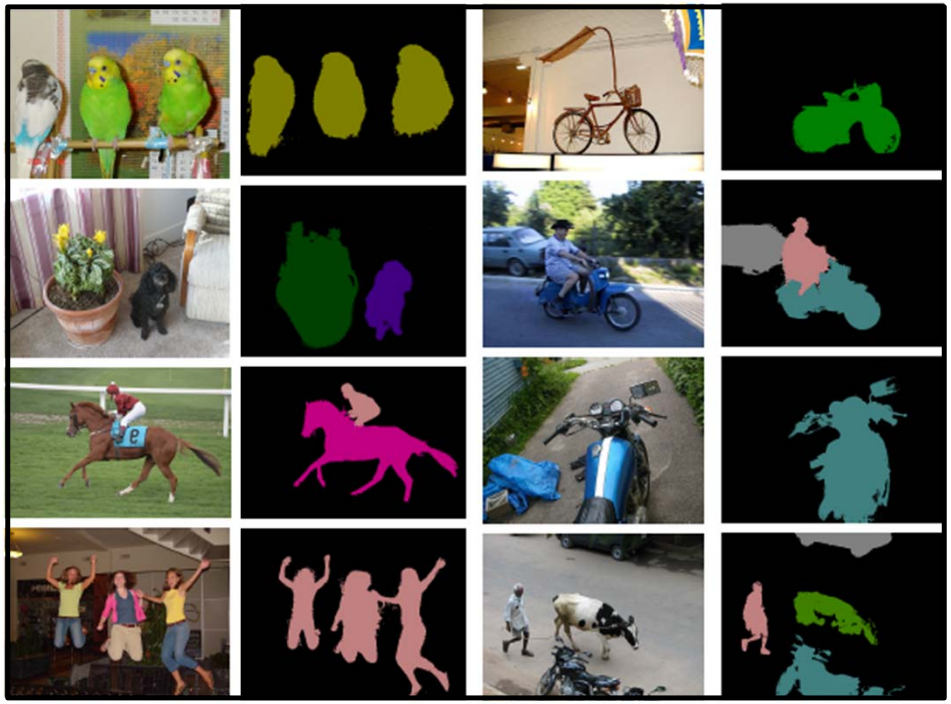


Subcortical structures
(Dolz et al., Neuroimage 2018)

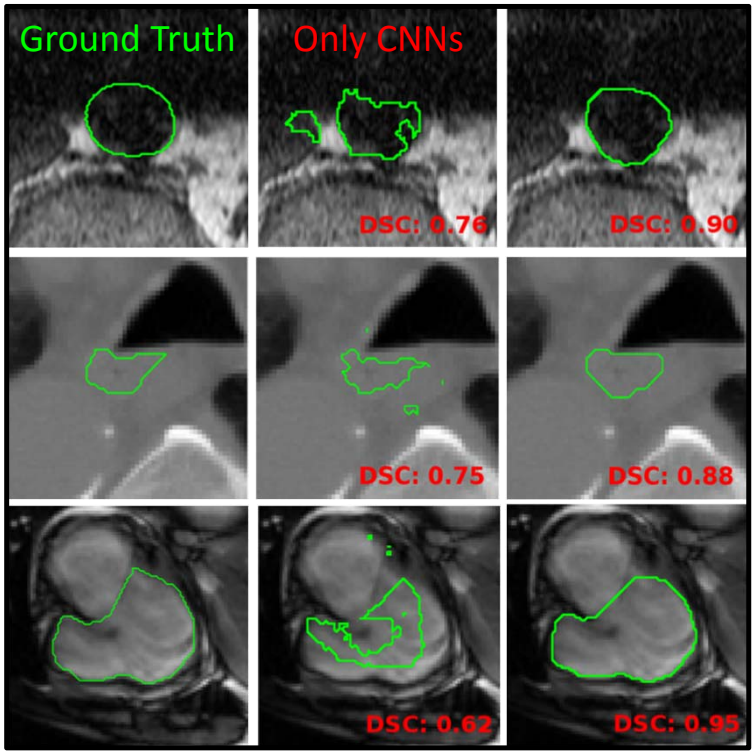


Vascular structures
(Ben Ayed et al., MICCAI 2014)

Semantic image segmentation:
Medical vs. Natural



Lot of annotated data
(millions)

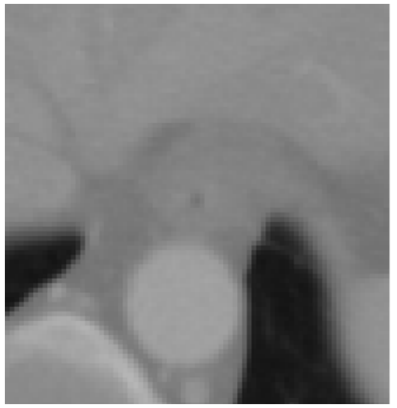


Lack of annotated data
(few subjects)

Why medical image interpretation is difficult

Annotations require expertise

Who knows where the horse is?

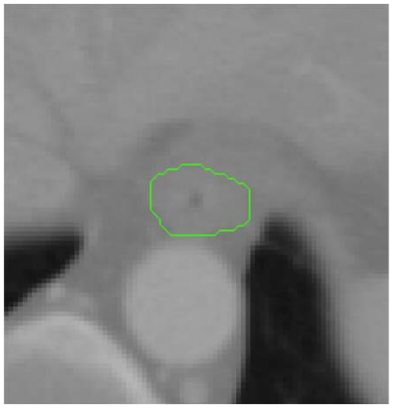


Who knows where the esophagus is?

Why medical image interpretation is difficult

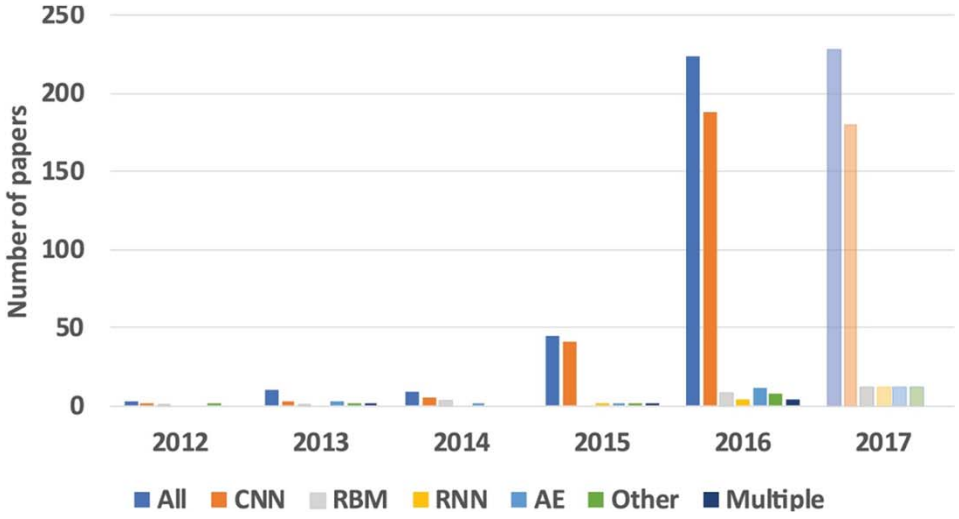
Annotations require expertise

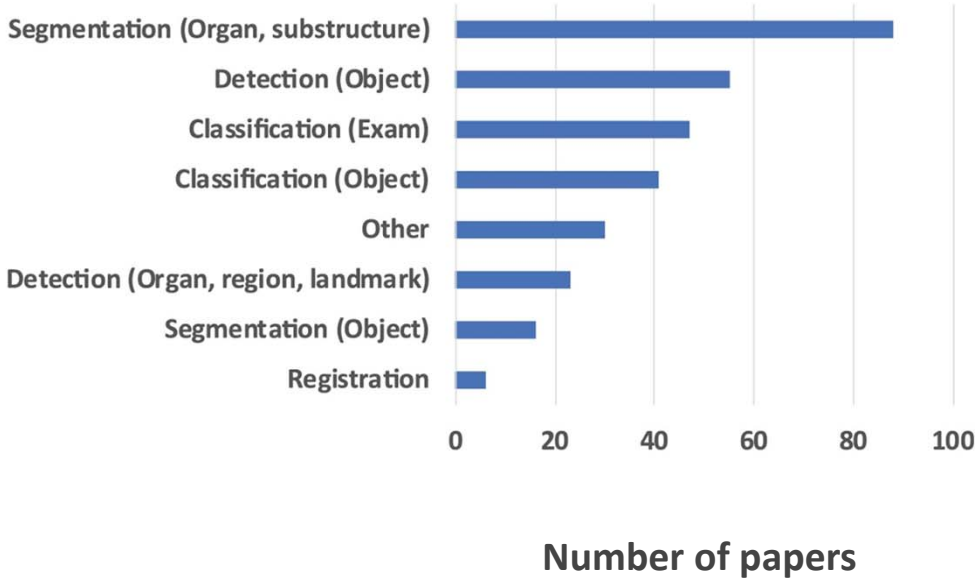
Who knows where the horse is?



Who knows where the esophagus is?

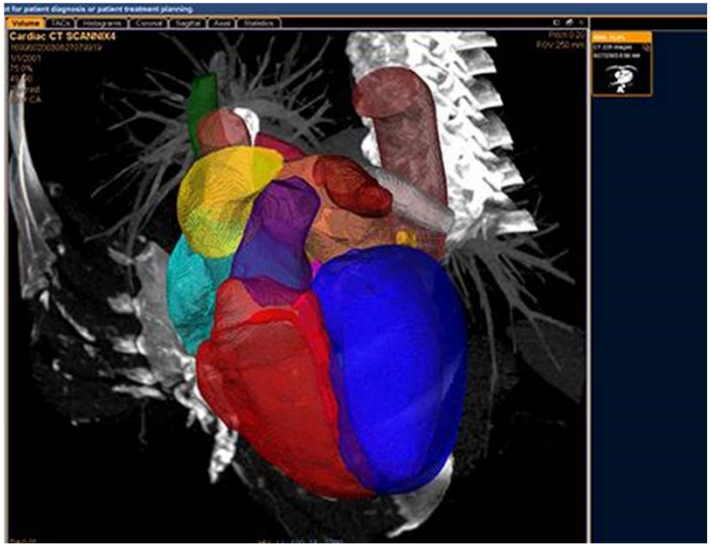
Deep learning papers for medical image segmentation:
>40-50% at MICCAI 2017

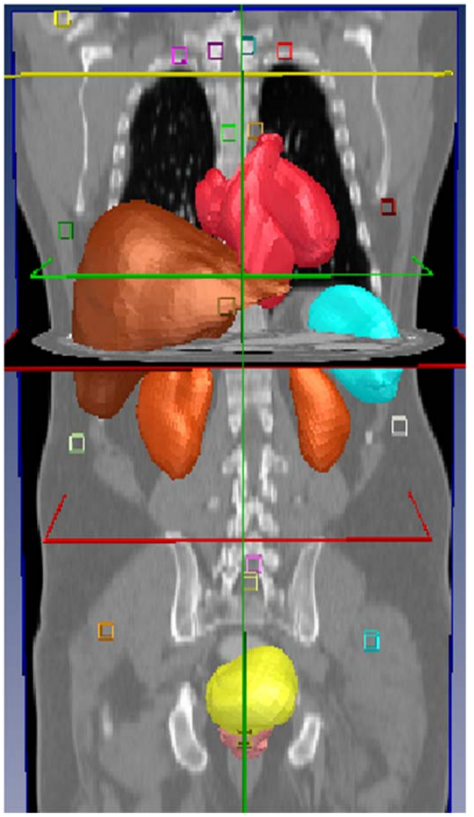


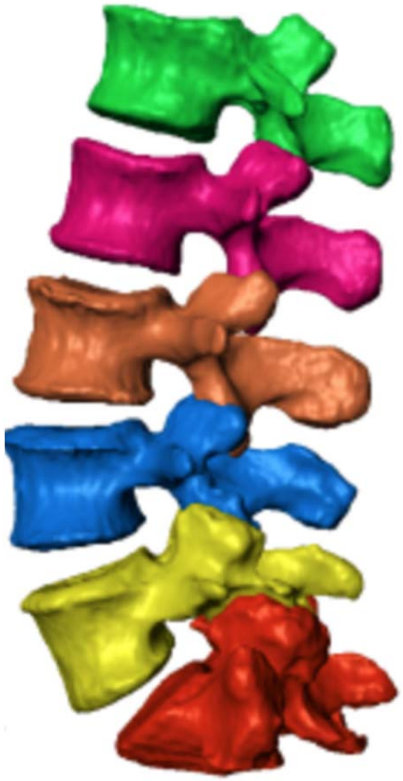


[Litjens et al., MedIA 2017]

Constraints (anatomical knowledge, radiology reports)







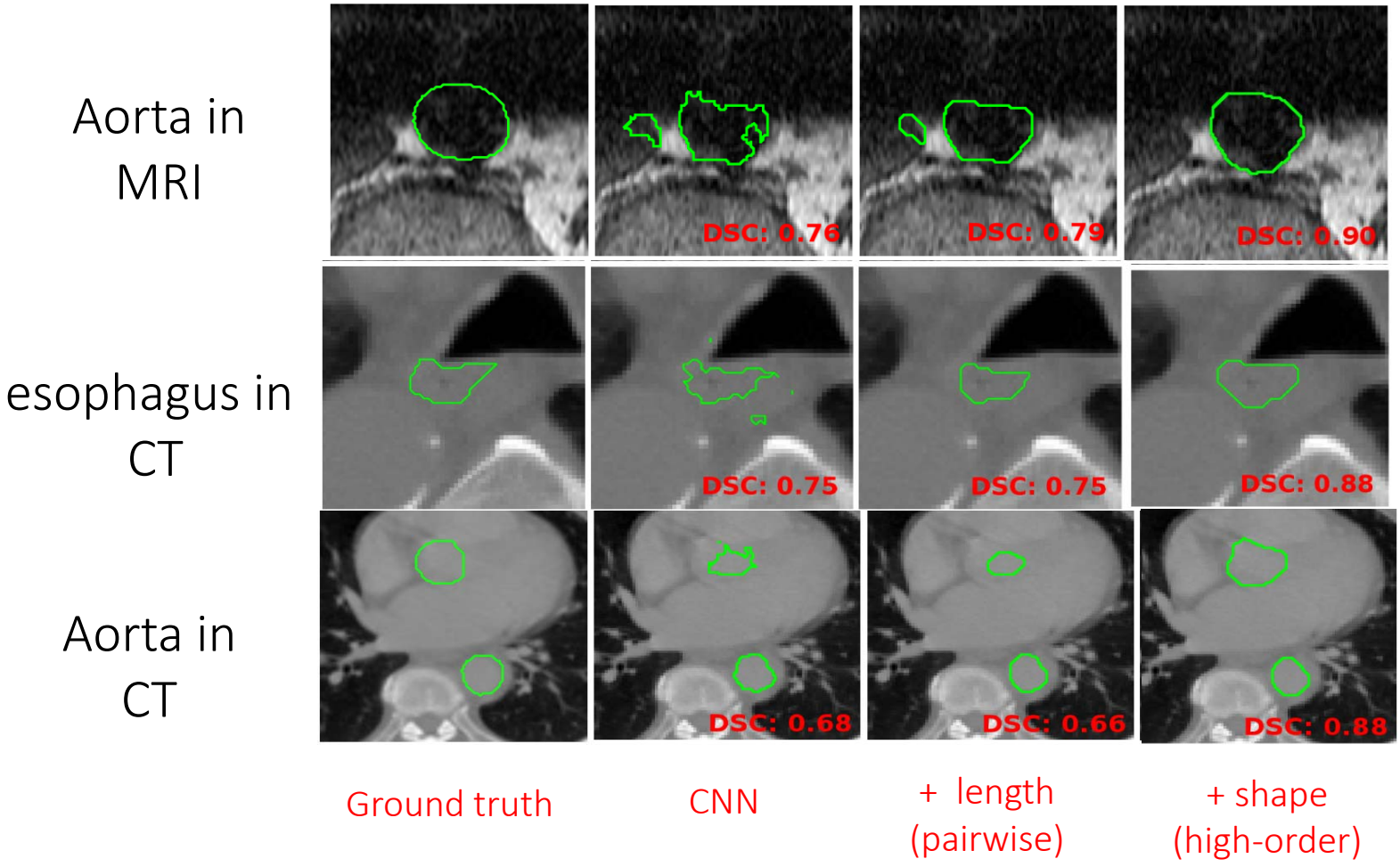
Almost no annotated data

Anatomical priors (**structured models**)?

Medical knowledge (**weak annotations**)?

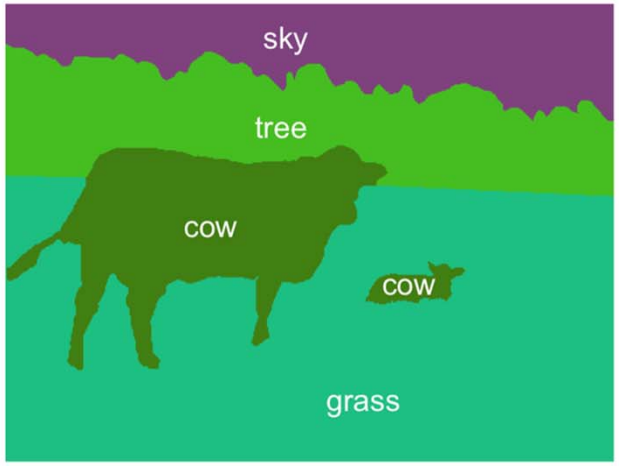
Suggestive annotations (**active learning**)?

Not enough annotated data: Guiding deep nets with priors

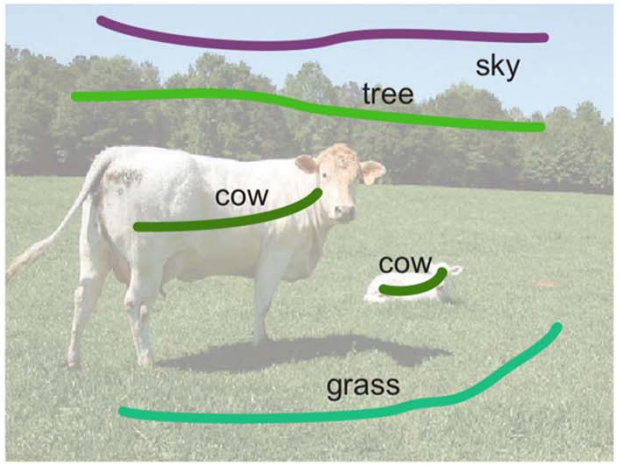


[Dolz et al., MICCAI 2017]

What about a lot of non-annotated data:
with a little bit of annotations



Full annotations

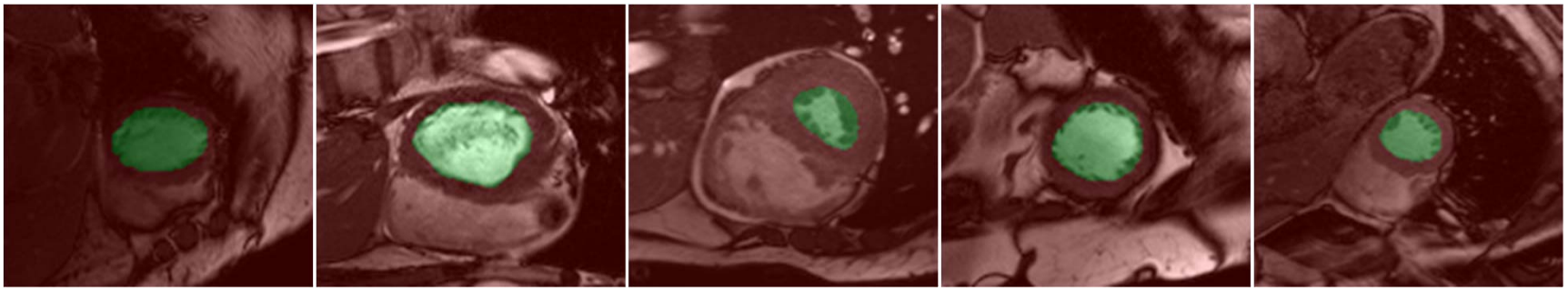


Semi-supervised

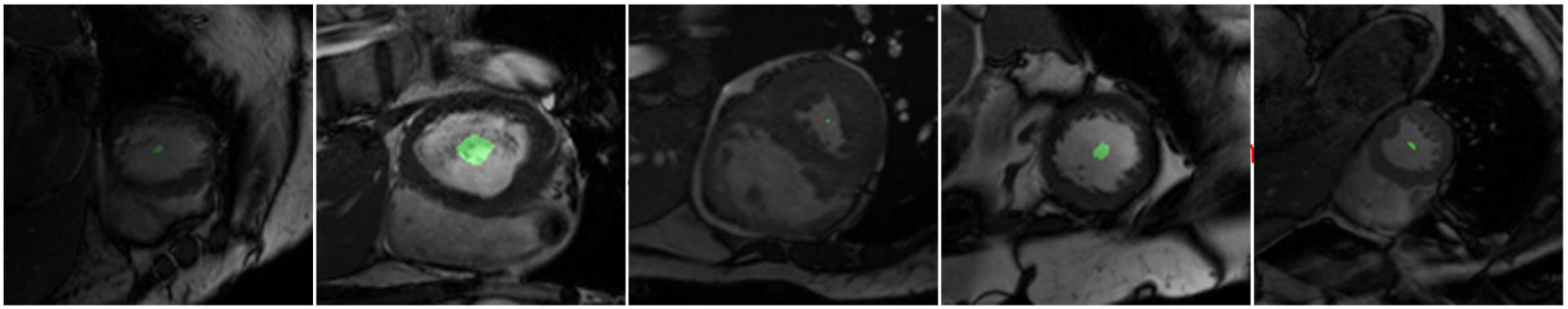
[Lin et al., CVPR 2016]

What about a lot of non-annotated data:
with a little bit of annotations

[Kervadec et al., MIDL 2018]



Full annotations



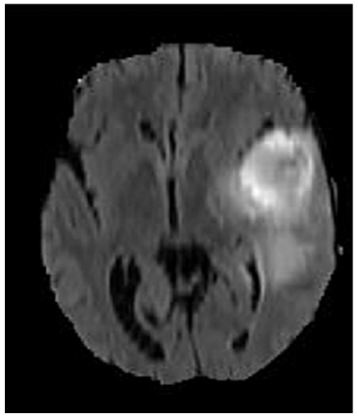
Semi-supervised

What about a lot of non-annotated data:

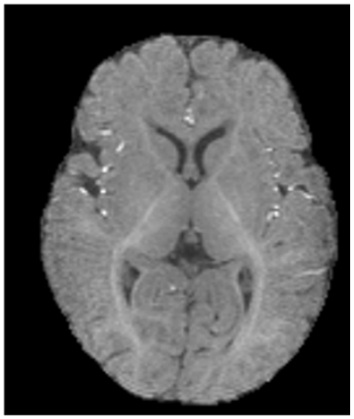
with weak annotations, e.g. image tags

[Kervadec et al., MIDL 2018]

Tumor



No tumor

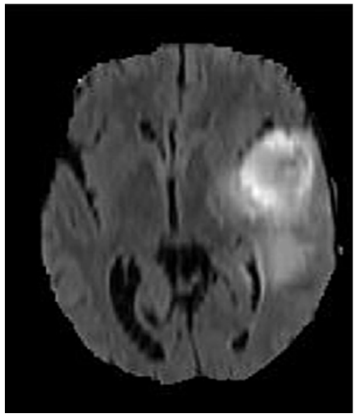


Training with this

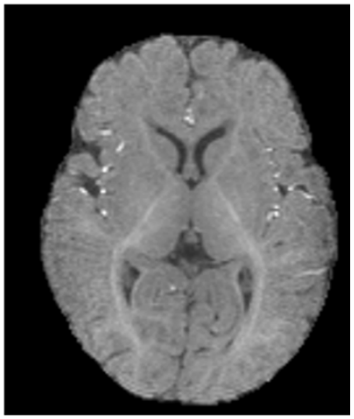
What about a lot of non-annotated data:
with weak annotations, e.g. image tags

[Kervadec et al., MIDL 2018]

Tumor

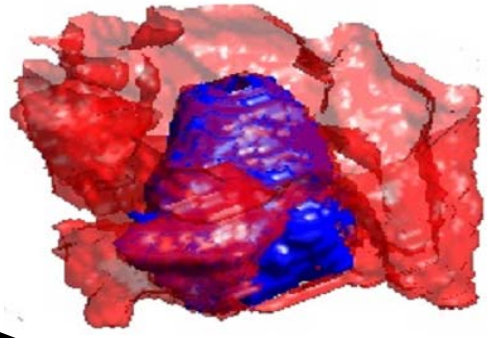


No tumor



Training a machine with this

Already available info (Rad reports)

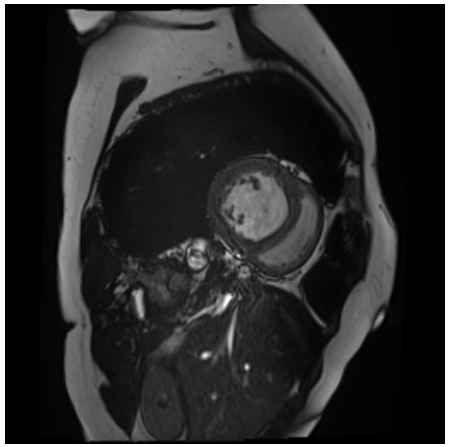


Can we get this

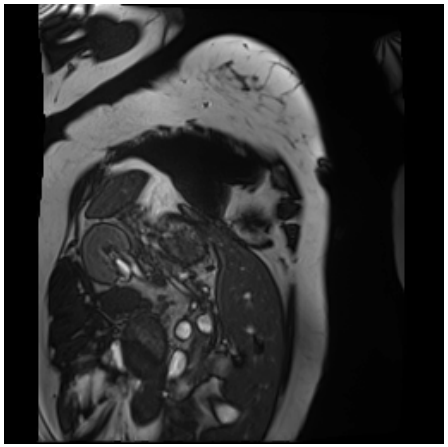
What about a lot of non-annotated data:
with weak annotations, e.g. image tags

[Kervadec et al., MIDL 2018]

Heart cavity



No heart cavity

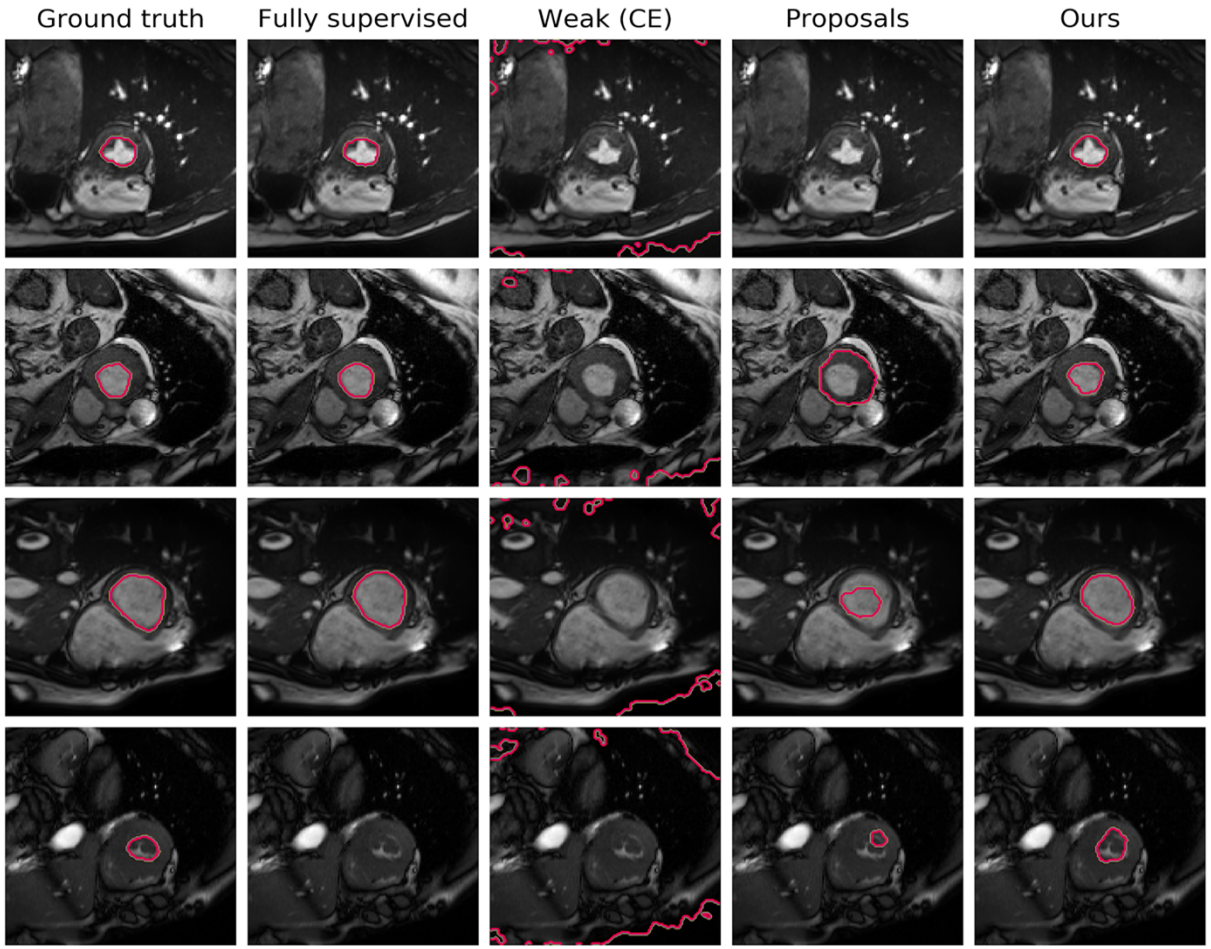


Training a machine with this
Easily available info

Can we get this

Yes, we can…

[Kervadec et al., MIDL 2018]



Some exciting results: Left Ventricle in MRI

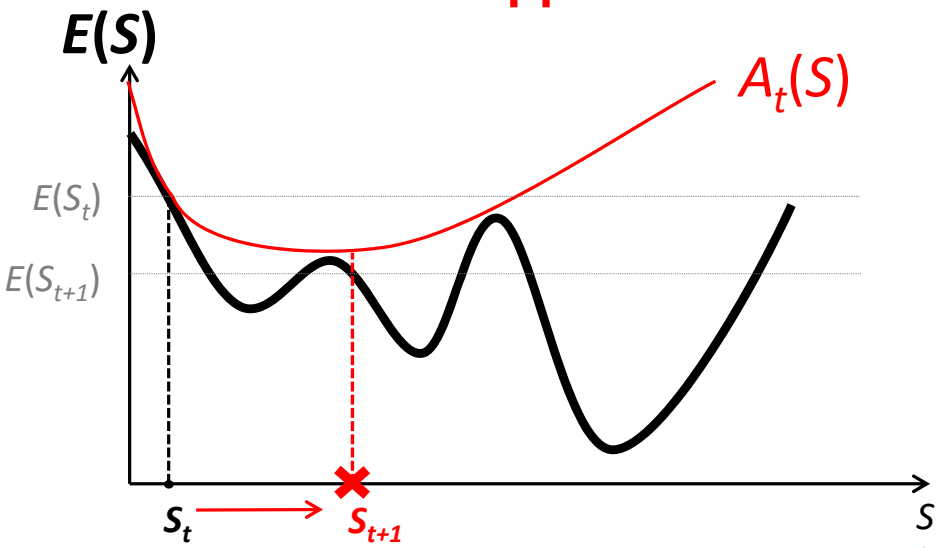
	Method	DSC (Val)
Weakly supervised	Cross-Entropy	0.0721
	Proposals (one bound)[1]	0.6124
	Proposals (one bound)[2]	0.0659
	Cross-Entropy + Size loss (one bound)[1]	0.8107
	Cross-Entropy + Size loss (one bound)[2]	0.8189
	Cross-Entropy + Size loss (two bounds)	**0.8415**
Fully supervised	—	0.9284

[1]Loose bound / [2]Tight bound

We achieve **90%** of full supervision performance with **0.1%** of annotated pixels.

Technical challenges:
Is this all about optimization?

Bounds/approximations?



Very large variables:
~ Millions

Complex constraints

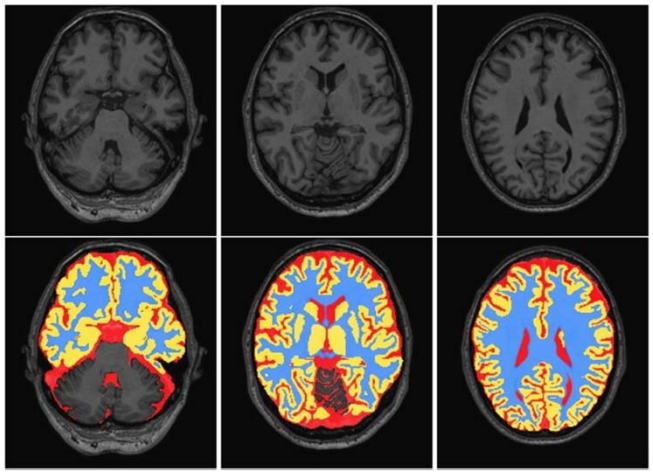
- Dolz et al., CVPR'17
- Tang et al., *ECCV'*16 (oral)
- Ben Ayed et al.,*TPAMI'*15
- Gorelick et al., *CVPR'*14 (oral), TPAMI'17
- Ben Ayed et al., *CVPR'*2013 (oral)

The team achieved this recently…

MICCAI MRBrainS challenge

Dataset:

- 3 MRI Modalities
- Training: 5 subjects
- Testing: 15 subjects



- 49 International teams

MRBrainS
Evaluation framework for MR Brain Image Segmentation

KTH ROYAL INSTITUTE OF TECHNOLOGY

UMC Utrecht

UNIVERSITÄT BERN

ViCOROB
COMPUTER VISION AND ROBOTICS RESEARCH INSTITUTE

Western

JOHNS HOPKINS
WHITING SCHOOL of ENGINEERING

Erasmus MC
Universitair Medisch Centrum Rotterdam

UNC
DEPARTMENT OF COMPUTER SCIENCE

The team achieved this recently…

Challenge rank

http://mrbrains13.isi.uu.nl/results.php

Rank	Team name	Submission name	Date	Sum Scores
1	LIVIA_ETS	HyperDenseNet[2]	06-02-18	54
2	TailHot	Hybrid Segmentation Network[2]	11-04-18	61
3	CU_DL2	3D Deep Learning; voxnet2	28-06-16	62
4	CU_DL	3D Deep Learning; voxnet1[3]	16-06-16	64
5	LRDE	Fully Convolutional Network	20-12-16	68
6	MSL-SKKU	Deep Convolutional Neural Network	19-06-17	69
7	MDGRU	Multi-Dimensional Gated Recurrent Units[3]	27-07-16	91
8	FBI/LMB Freiburg	U-Net (3D)	01-05-16	94
9	PyraMiD-LSTM2	NOCC with rounds[3]	23-05-16	95
10	AOC	Atlas of Classifiers	24-12-17	106
11	IDSIA	PyraMiD-LSTM	05-06-15	114
12	STH	Hybrid ANN-based Auto-context method[2]	03-06-16	124
13	ISI-Neonatology	Multi-stage voxel classification	31-05-14	129
14	UNC-IDEA	LINKS:Learning-based multi-source integration	09-02-15	135
15	MNAB2	Random Forests	21-02-14	157
16	KSOM GHMF	ASeTs: MAP-Based with Manifold learning	13-05-14	159
17	vicorob UdG T1_F	MSSEG using T1 + FLAIR (T1-IR skull)	14-01-16	180
18	VBM12	VBM12_r738 with WMHC=2	07-10-15	182
19	BIGR2	Multi-Feature SVM Classification	26-09-13	184
20	WTA	3D Cascade convolutional architecture	06-02-18	191

Acknowledgments

ETS Research Chair:
AI in Medical Imaging

Acknowledgments

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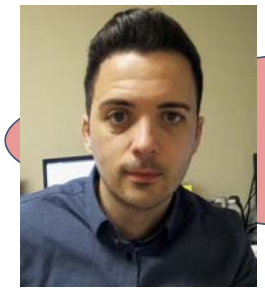
J. Dolz
Post-doc


C. Desrosiers
Professor


H. Lombaert
Professor


E. Granger
Professor


K. Gopinath
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H. Kervadec
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