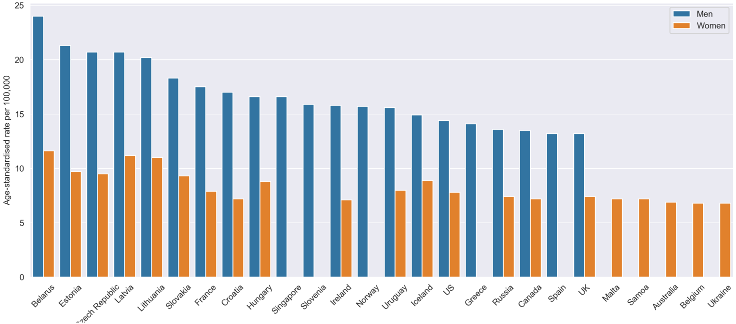
Kidney Tumor Segmentation

Machine Learning Course
Project Proposal
March 2019

Olexander Chepurnoi
Yaroslava Lochman

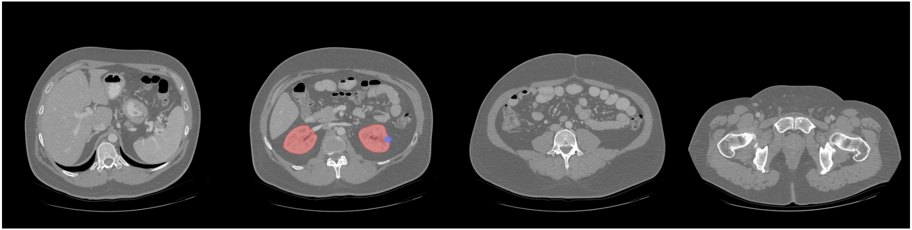
Motivation. Kidney Cancer Statistics



- There are more than 400,000 new cases of kidney cancer each year[1]
- And surgery is its most common treatment[2]
- Automatic semantic segmentation is a promising tool for developing advanced surgical planning techniques, but morphological heterogeneity makes it a difficult problem.

[1] Kidney Cancer Statistics 2018, www.wcrf.org/dietandcancer/cancer-trends/kidney-cancer-statistics
[2] Cancer Diagnosis and Treatment Statistics 2017, www.cancerresearchuk.org/health-professional/cancer-statistics/diagnosis-and-treatment

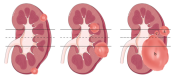
Data: Arterial Phase abdominal CT scans (volumetric images)
Goal: Kidney semantic segmentation



In total: data of 300 unique kidney cancer patients (who underwent partial or radical nephrectomy):
- 210 for training
- 90 will be used for evaluation

- Multivariate Analysis, Scoring Systems[1],[2]

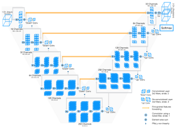
	1pt	2pts	3 pts
(R)adius (maximal diameter in cm)	≤4	>4 but < 7	≥ 7
(E)xophytic/endophytic properties	≥ 50%	<50%	Entirely endophytic
(N)earness of the tumor to the collecting system or sinus (mm)	≥7	>4 but <7	≤4
(A)nterior/Posterior	No points given. Mass assigned a descriptor of a, p, or x		
(L)ocation relative to the polar lines* * suffix "h" assigned if the tumor touches the main renal artery or vein	Entirely above the upper or below the lower polar line	Lesion crosses polar line	>50% of mass is across polar line (a) or mass crosses the axial renal midline (b) or mass is entirely between the polar lines (c)

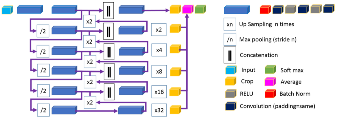


Anatomical features*	Score
Longitudinal (polar) location	
Superior/inferior	1
Middle	2
Exophytic rate	
≥50%	1
<50%	2
Endophytic	3
Renal rim	
Lateral	1
Medial	2
Renal sinus	
Not involved	1
Involved	2
Urinary collecting system	
Not involved	1
Dislocated/infiltrated	2
Tumour size (cm)	
≤4	1
4.1–7	2
>7	3

* Anterior or posterior face can be indicated with a letter ("a" or "p") following the score.

- Convolutional Neural Networks[3],[4]





[1] Kutikov, Alexander, and Robert G. Uzzo. "The RENAL nephrometry score: a comprehensive standardized system for quantitating renal tumor size, location and depth." (2009)

[2] Ficarra, Vincenzo, et al. "Preoperative aspects and dimensions used for an anatomical (PADUA) classification of renal tumours in patients who are candidates for nephron-sparing surgery." (2009)

[3] Milletari, Fausto, et al. "V-Net: Fully Convolutional Neural Networks for Volumetric Medical Image Segmentation." (2016)

[4] Taha, Ahmed, et al. "Kid-Net: Convolution Networks for Kidney Vessels Segmentation from CT-Volumes." (2018)

- Data: 38GB of 210 Tensors

- Preprocessing:

  + Libraries: NiBabel (NeuroImaging in Python) + NumPy + SciPy + OpenCV

  + First Steps: Normalization, Stratified Train-Val Splitting, Augmentaions

- Preparation Steps: Encoder-Decoder 3D-Convolutional Neural Network (similar to V-Net): it was shown[1] that U-shaped class of models with additional techniques efficients deals with Biomedical Image Segmentation problems.

- ML Library: PyTorch

[1] Ronneberger, Olaf, et al. "U-Net: Convolutional Networks for Biomedical Image Segmentation." (2015)