ICSC
Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

Radiomics and AI techniques: selected experimental results on medical images of lung cancer, neurological diseases and COVID-19

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CT and MRI radiomic features of lung cancer (NSCLC): comparison and software consistency

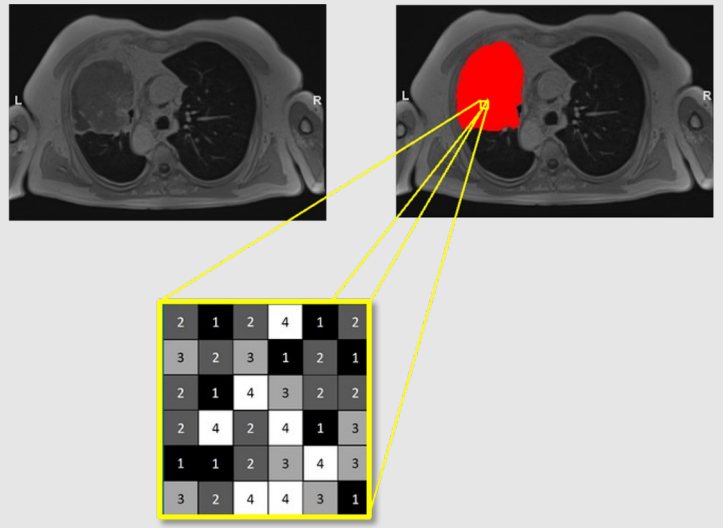
Fondazione IRCCS Policlinico San Matteo

Prof. Lorenzo Preda
Dr. Chandra Bortolotto

RADIOMICS

Radiomics is a **quantitative method** that allows the extraction of mineable data from medical imaging to improve:

- diagnosis
- prognostication
- clinical decision support

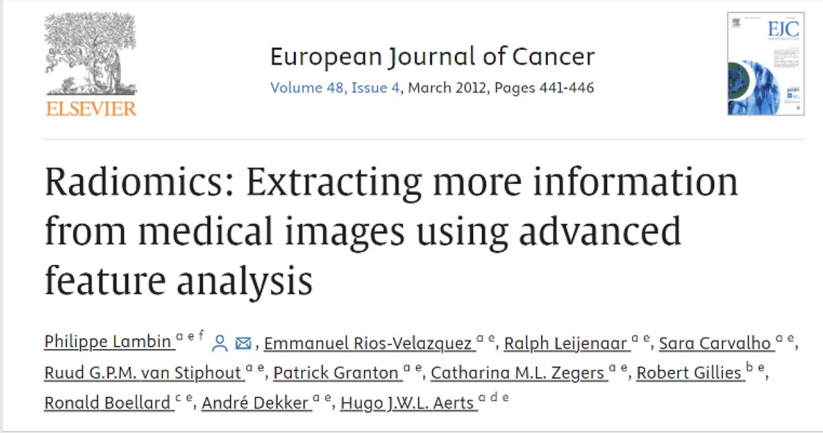


First definition:

Radiomics focuses on improvements of image analysis, using an automated high-throughput extraction of large amounts (200+) of quantitative features of medical images and belongs to the last category of innovations in medical imaging analysis.

Tissue details and heterogeneity

Image intensity distribution


ELSEVIER
European Journal of Cancer
Volume 48, Issue 4, March 2012, Pages 441-446
EJC

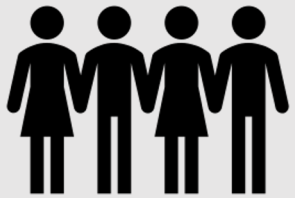
Radiomics: Extracting more information from medical images using advanced feature analysis

Philippe Lambin [a e f], Emmanuel Rios-Velazquez [a e], Ralph Leijenaar [a e], Sara Carvalho [a e], Ruud G.P.M. van Stiphout [a e], Patrick Granton [a e], Catharina M.L. Zegers [a e], Robert Gillies [b e], Ronald Boellard [c e], André Dekker [a e], Hugo J.W.L. Aerts [a d e]

AIM OF THE STUDY

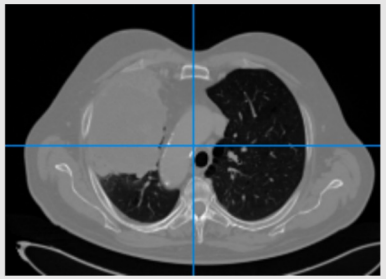
To investigate the **agreement between two open-source radiomics software** (LIFEx and PyRadiomics) for both contrast-enhanced **CT** and contrast-enhanced **MRI** of **lung cancers** and to preliminary **evaluate the existence of radiomic features stable for both techniques**.

METHODS

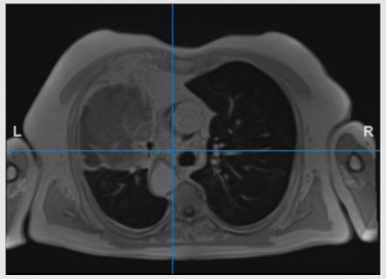


35 patients
with NSCLC

CT images

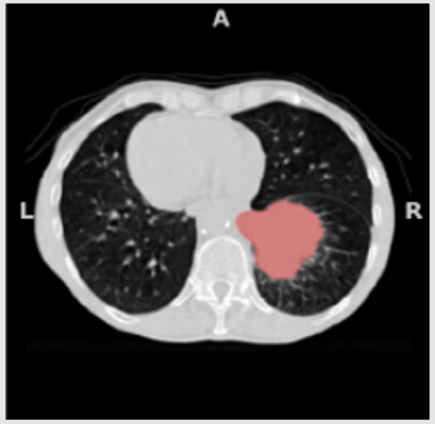


MRI images



ROI segmentation

semiautomatically (Hounsfield unit seed-based method)



manually

Image preprocessing and radiomic features extraction

- **no resampling**
- setting resampling voxel dimensions **directly on the software**
- images resampled using the Python package **Nibabel before features extraction**

Correlation assessment with ICC calculation

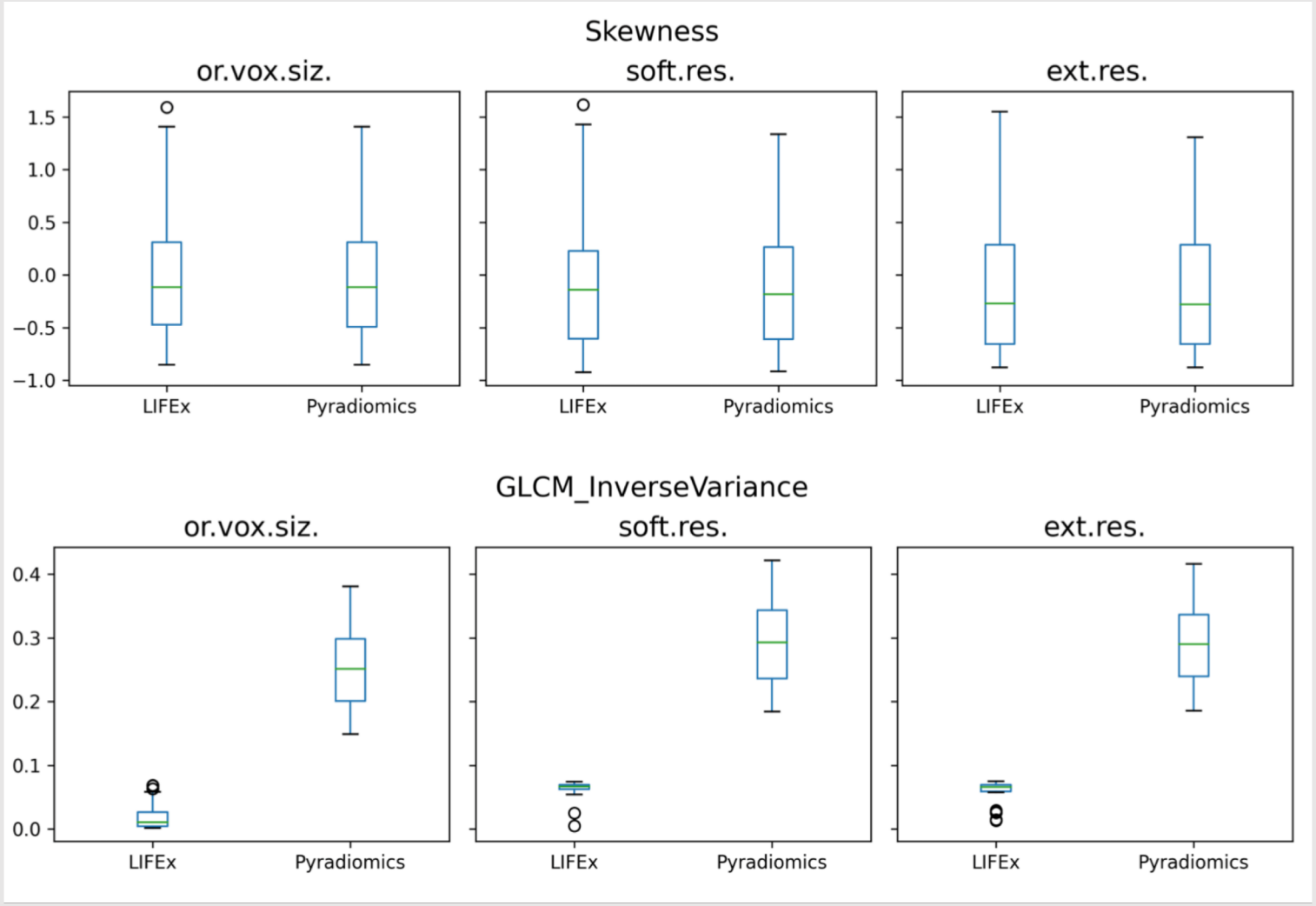
between LIFEx and PyRadiomics

between MRI and CT imaging modalities

RADIOMIC FEATURES distribution

feature with excellent reliability
(Skewness)

feature with poor reliability
(Gray Level Co-occurrence Matrix
Inverse Variance)



No resampling
(original voxel-size)

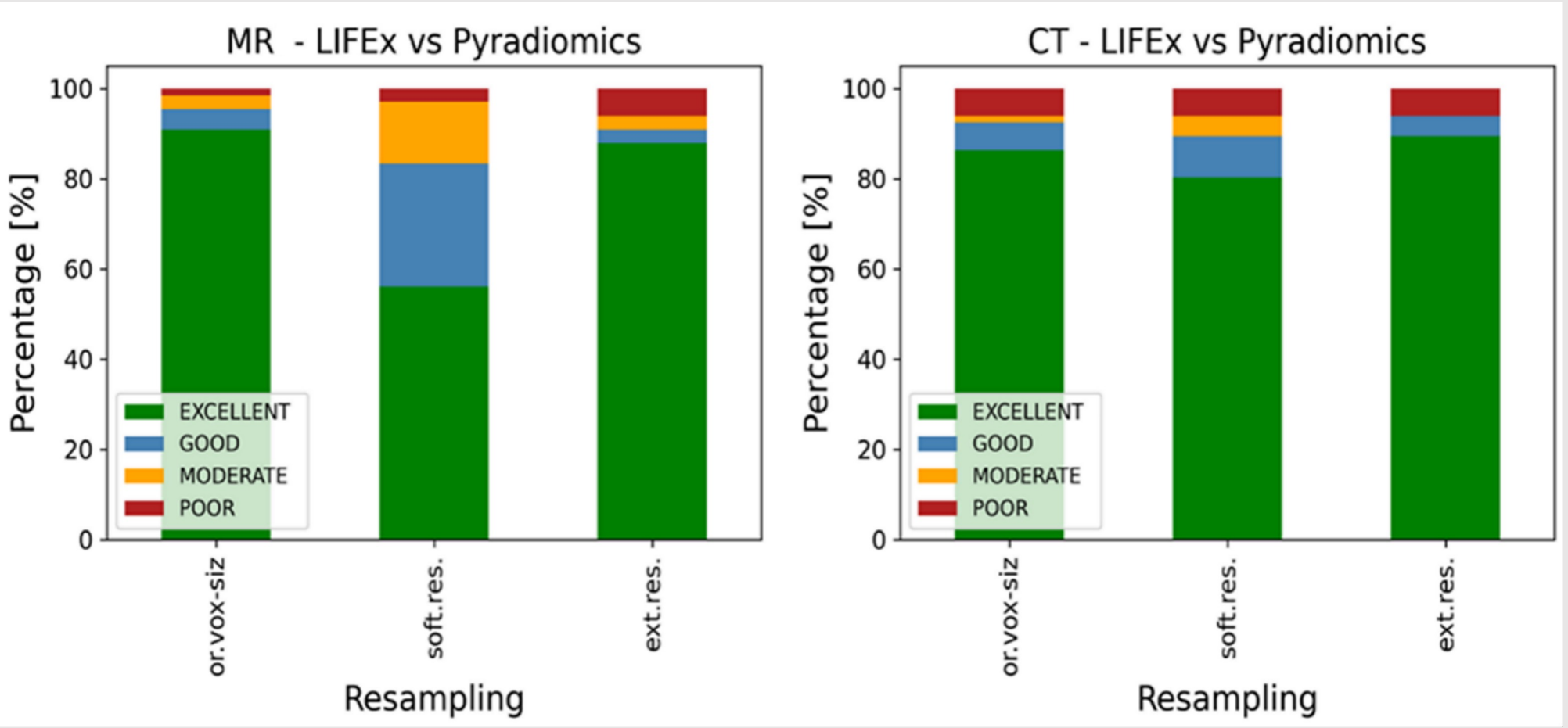
LIFEx/Pyradiomics
(software resampling)

Nibabel
(external resampling)

LIFEx *vs* PyRadiomics

ICC values into four ranges of reliability:

- poor (ICC < 0.5)
- moderate (0.5 ≤ ICC < 0.75)
- good (0.75 ≤ ICC < 0.9)
- excellent (ICC ≥0.9)



Software agreement

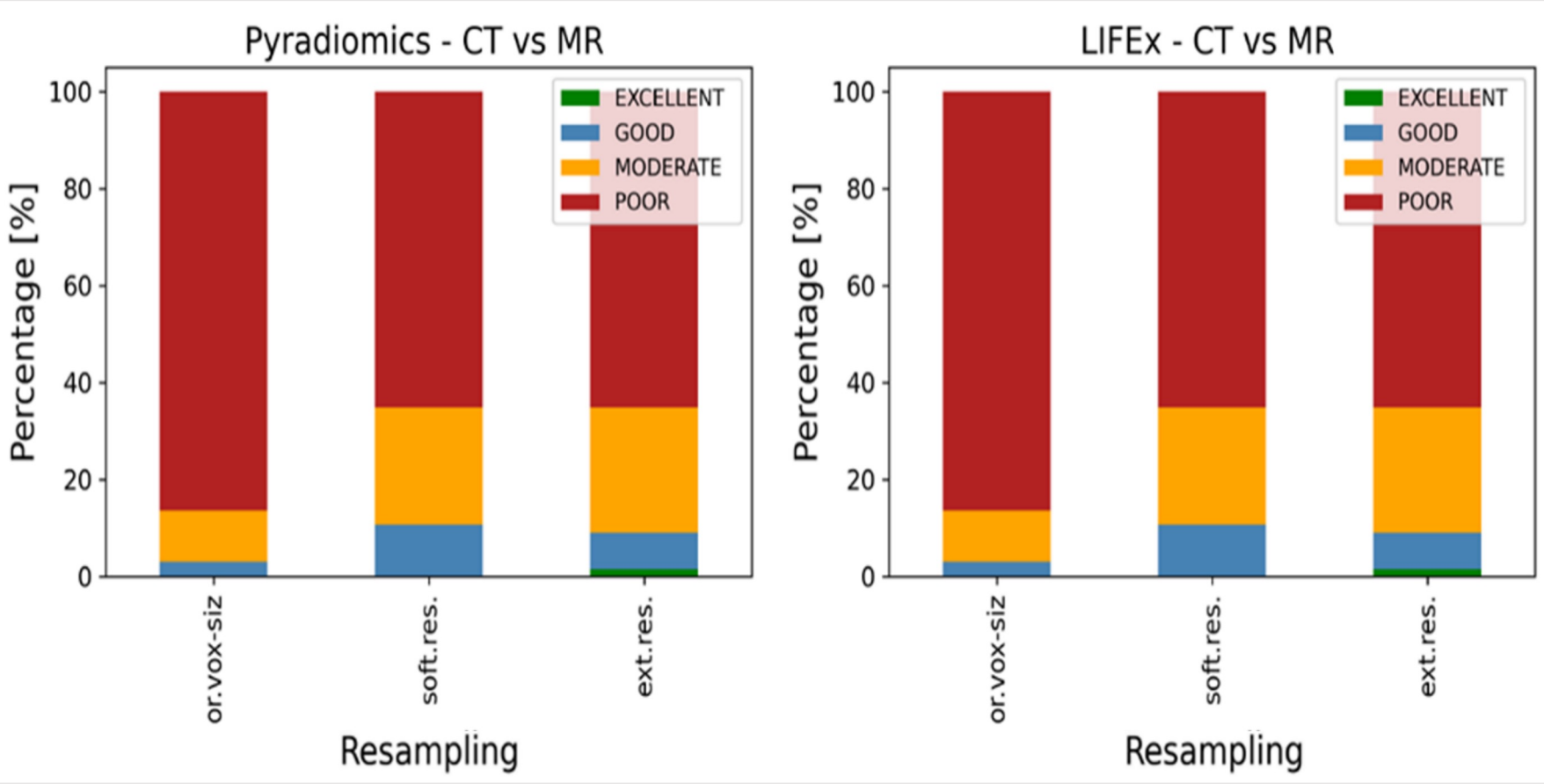
Minimum agreement: internal resampling
→ different resampling algorithms (LIFEx/PyRadiomics)

CT: original voxel dimensions closer to the isotropic voxel size
→ less impact of resampling

CT *vs* MRI

ICC values into four ranges of reliability:

- poor (ICC < 0.5)
- moderate (0.5 ≤ ICC < 0.75)
- good (0.75 ≤ ICC < 0.9)
- excellent (ICC ≥0.9)



Most information not directly translatable from one image technique to the other

~ 10% of MRI-CT related features (shape and texture) exhibited ICC ≥ 0.75

Features stable across modalities may carry relevant biological information related to lung cancer's characterization and options for treatment.

Selection features that are cross-modality and stable for the clinical translation of radiomic biomarkers.

Bortolotto, C., Pinto, A., Brero, F., Messana,... & Preda, L. (2024). CT and MRI radiomic features of lung cancer (NSCLC): comparison and software consistency. European Radiology Experimental, 8(1), 1-12.

Neural Network for fast MR parameters mapping in Neuromuscular Disorders

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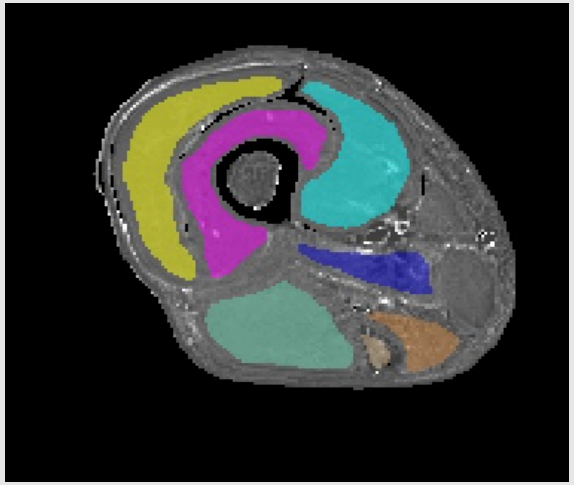
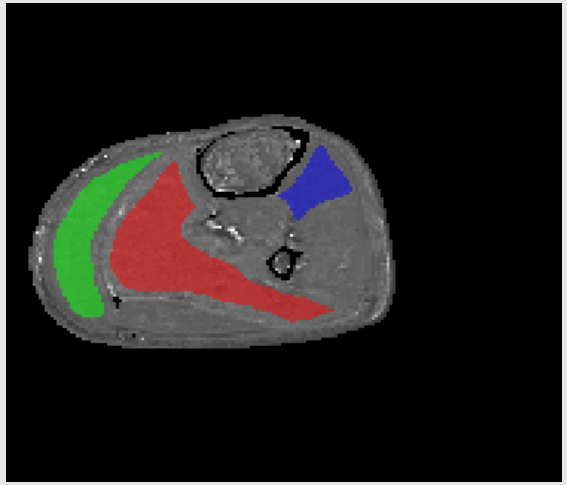
Prof. Anna Pichiecchio

AIM OF THE STUDY

To develop and evaluate a neural network for accurate and fast **Fat Fraction (FF), water-T2 (wT2) and B1 mapping** from a heterogeneous cohort of Neuromuscular Disorders.





METHODS

The study was motivated by the growing interest of the muscle MRI community in quantitative radiological biomarkers for investigating the progression of neuromuscular disorders. FF and wT2 are sensitive to the percentage of fat replacement in muscle, the muscle fiber necrosis, inflammation and denervation processes.

Cohort:

103 subjects with NMDs

30 facioscapulohumeral dystrophy (FSHD)
25 amyotrophic lateral sclerosis (ALS)
20 glycogen-storage disease type II (GSD-IIa)
13 antisynthetase syndrome (ASSD)
15 skeletal muscle channelopathies (n = 15)

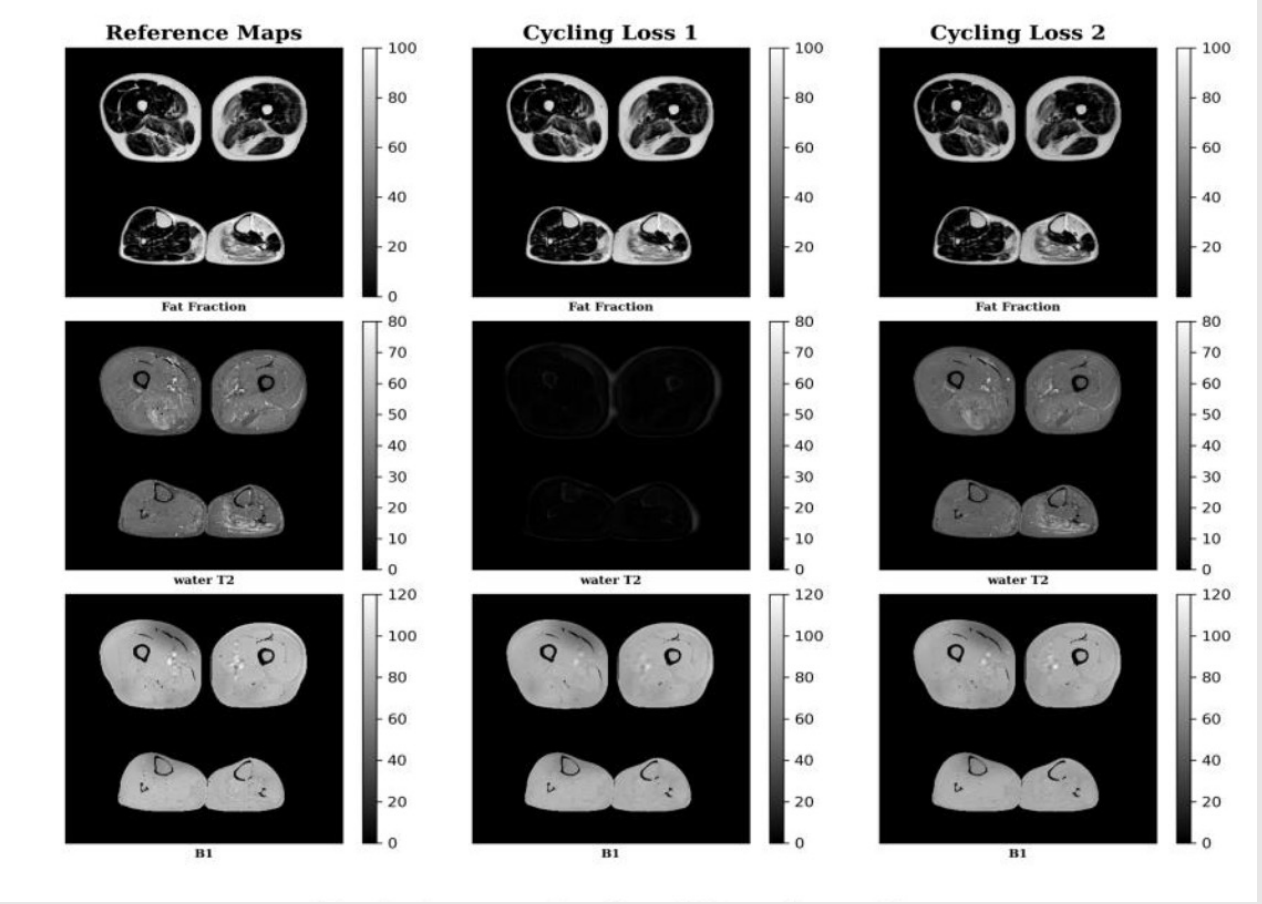
44 healthy controls

Acquisition:

Lower limb MRI using a 17-echoes Multi-Echo Spin Echo (MESE) sequence (3 T MRI scanner)

METHODS

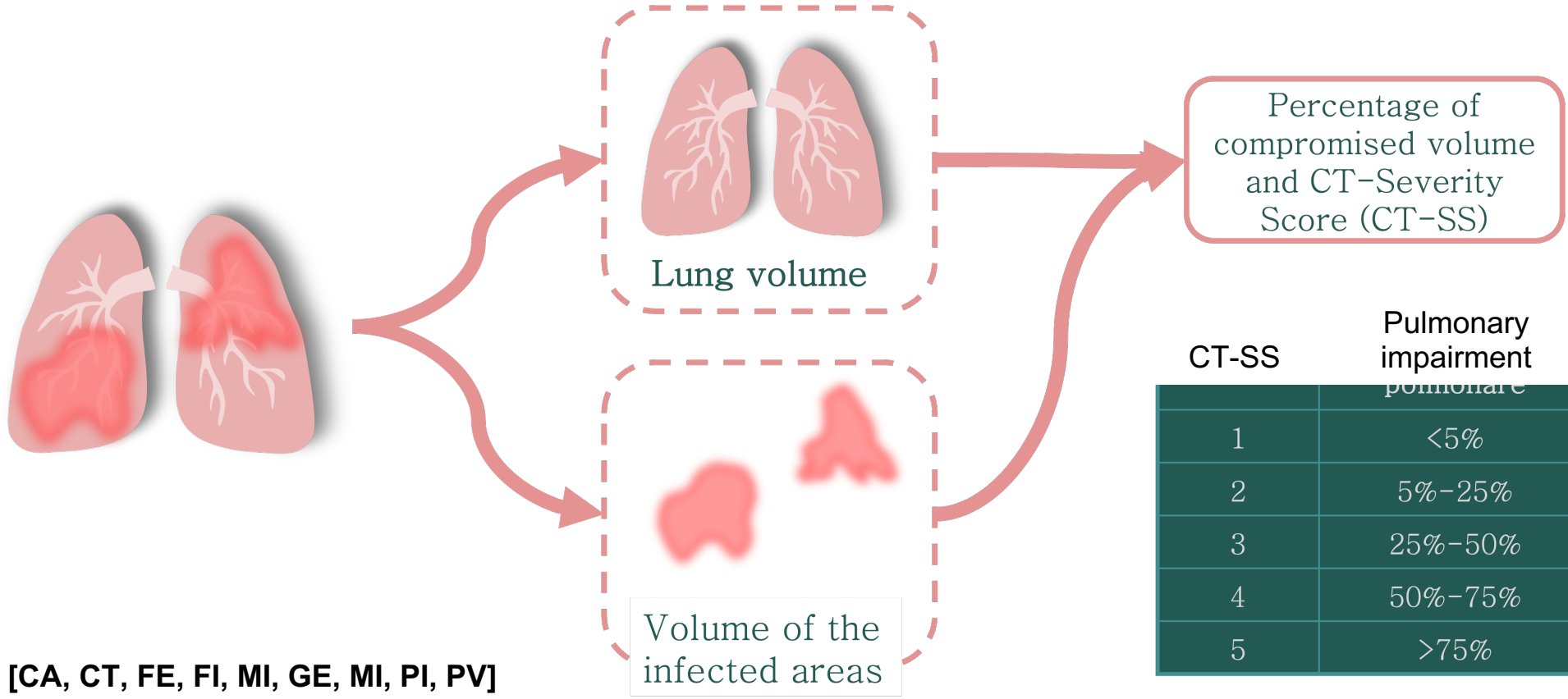
From 2164 slices, FF, wT2, and B1 maps were computed (g.t.).
A custom U-Net translated input to MR parameter maps. Two physics-based loss functions with an exponential model and with EPG theory, improved consistency between predicted and input k-space data.



Quantification of pulmonary involvement in COVID-19 pneumonia

AIM OF THE STUDY

To develop a DL algorithm that generates segmentation masks for lungs and COVID-19 lesions and calculates the percentage of affected lung volume, which is then converted into the CT severity score.

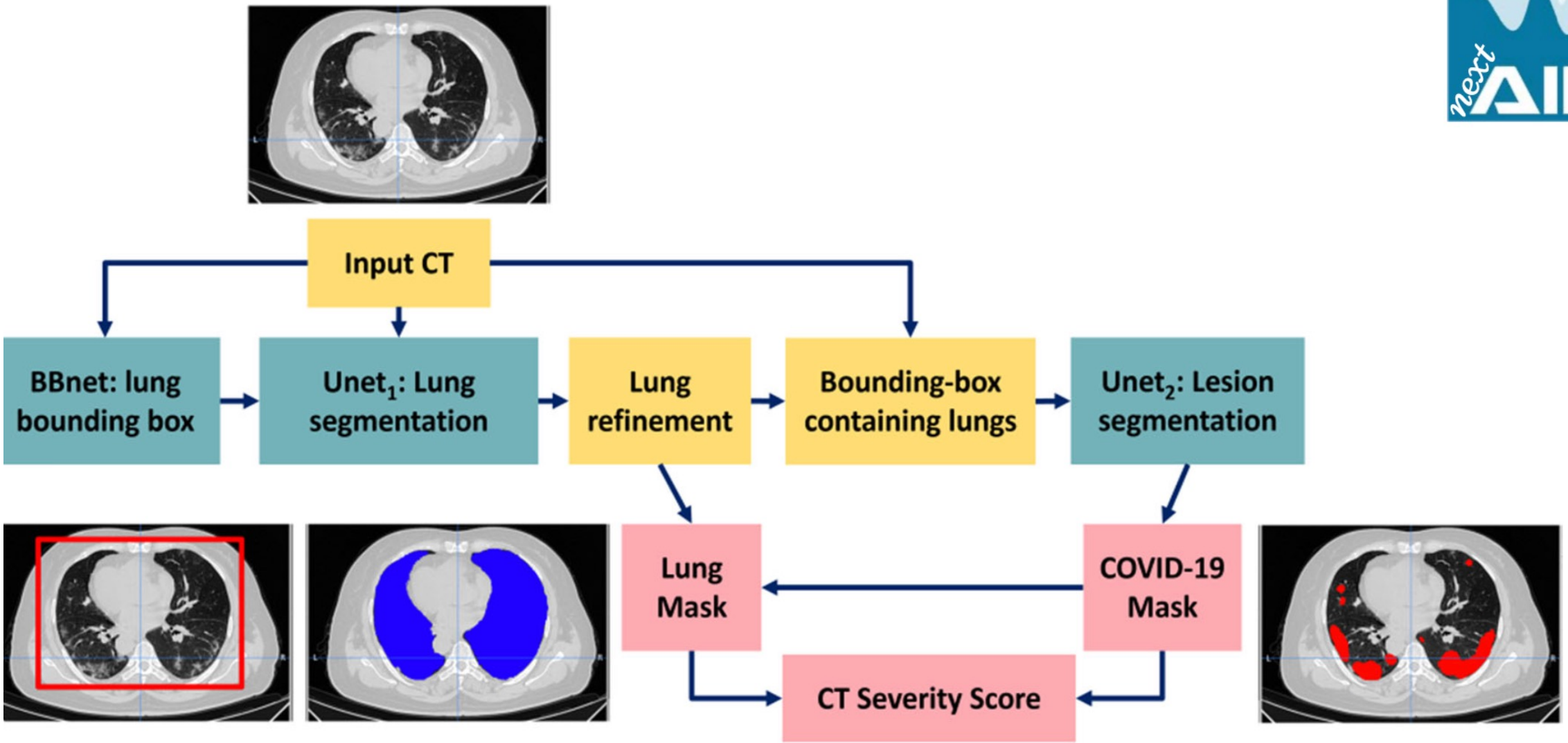


CT-SS	Pulmonary impairment
1	<5%
2	5%-25%
3	25%-50%
4	50%-75%
5	>75%

[CA, CT, FE, FI, MI, GE, MI, PI, PV]

METHODS

[https://www.openaccessrepository.it/record/76937]



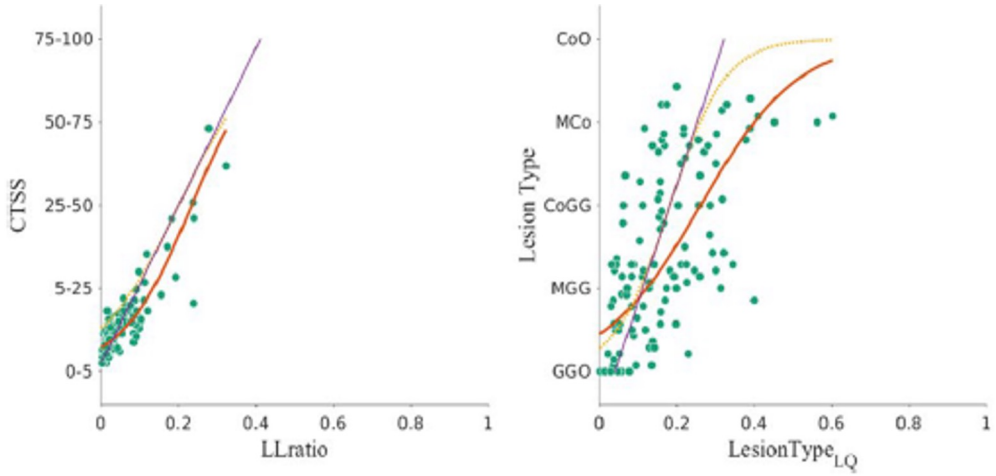
Lizzi F et al Quantification of pulmonary involvement in COVID-19 pneumonia by means of a cascade of two U-nets: training and assessment on multiple datasets using different annotation criteria. IJCARS 2022;17:229–37. doi.org/10.1007/s11548-021-02501-2.
Lizzi, Francesca, et al. "Quantification of pulmonary involvement in COVID-19 pneumonia: an upgrade of the LungQuant software for lung CT segmentation." *The European Physical Journal Plus*138.4 (2023): 1-10.

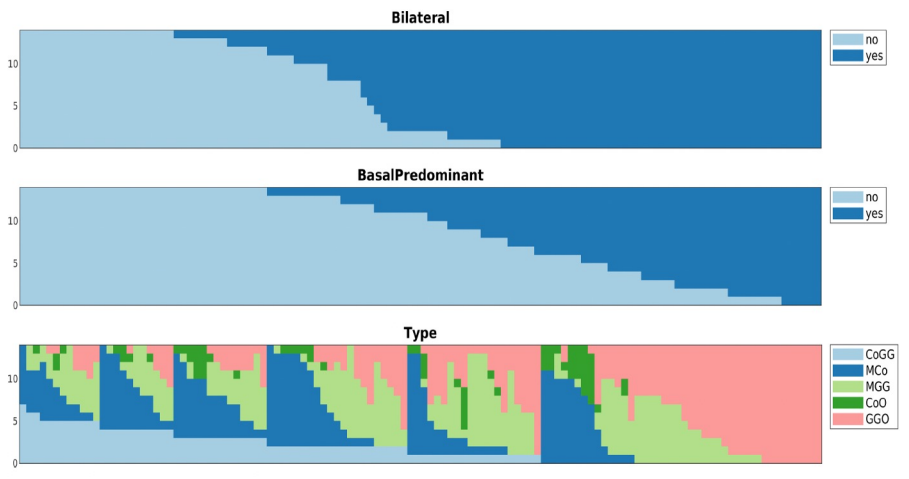
VALIDATION

SW output:
- segmented masks
- qualitative parameters to describe the lesions

ID	LESION_TYPE_INDEX	BILATERAL_INDEX	BASAL_INDEX
A-0037	0,137	0,447	37
A-0311	0,198	0,041	61
A-0291_0	0,224	0,193	31
A-0327	0,292	0,351	60
	$V_{Consolidation}$ / V_{Lesion}	0: unilateral 1: bilateral	0: basal 100: apical

The validation of the LungQuant software output against the qualitative assessment of 14 radiologists from 5 University Hospitals (Pisa, Pavia, Firenze, Palermo, Milano). The comparison was carried out on 120 publicly available CT. It has shown:
- a poor agreement among the opinions of radiologists
- a good correlation between average radiologists' opinions and the equivalent software output metrics





Chincarini A, Scapicchio C et al A multicenter evaluation of the LungQuant software for lung parenchyma characterization in COVID-19 pneumonia, European Radiology Experimental, https://doi.org/10.1186/s41747-023-00334-z

OTHER PROJECTS

Mapping T1 and T2 - For the validation of T1 and T2 MRI Mapping sequences on the lung

Micro-CT - Quantitative analysis and comparison between micro-imaging, conventional imaging, and post-lobectomy histological specimens.

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INFN - next_AIM group (Alessandra Retico)
Dr. Marta Filibian (Centro Grandi Strumenti - UniPV)

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