Artificial Intelligence in Medicine (AIM): *next steps*

focus on no-so-big data and explainable techniques

6 luglio 2023

https://www.pi.infn.it/aim/

AIM [2019-2021]
next_AIM [2022-2024]

A large variety of AI-based algorithms have already been developed to analyse medical images and data.
Their potential to improve clinical workflows has not yet been fully exploited due to:

- the lack of model robustness or generalizability
- the lack of transparency

next AIM goal: *to take steps towards developing robust and explainable AI algorithms and validating them on realistic use cases in the medical field*

next_AIM: breve descrizione ed obiettivi

Istituto Nazionale di Fisica Nucleare
Sezione di PISA

next_AIM
Resp. Naz.: A. Retico

13 INFN groups:
- Bari (S. Tangaro)
- Bologna (D. Remondini)
- Cagliari (P. Oliva)
- Catania (M. Marrale)
- Ferrara (G. Paternò)
- Firenze (C. Talamonti)
- Genova (A. Chincarini)
- Lab. Naz. Sud (G. Russo)
- Milano (C. Lenardi)
- Napoli (G. Mettivier)
- Padova (A. Zucchetta)
- Pavia (A. Lascialfari)
- Pisa (M.E. Fantacci)

Goal: *to take steps towards developing robust and explainable AI algorithms and validating them on realistic use cases in the medical field*

WP1

Challenge I: no-so-big data

Strategies for efficient learning with limited data samples.

Evaluation of robustness and reliability of trained models.

WP2

Challenge II: explainable AI (XAI)

Make AI results understandable to humans.

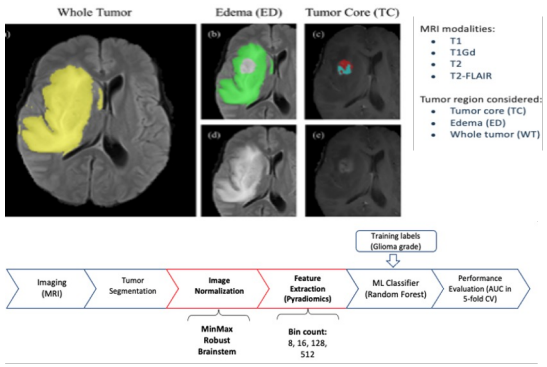
Which image/data features are relevant to make a decision?

Long-standing collaboration with Italian centers (hospitals and IRCCS) and with international consortia for data sharing

WP3

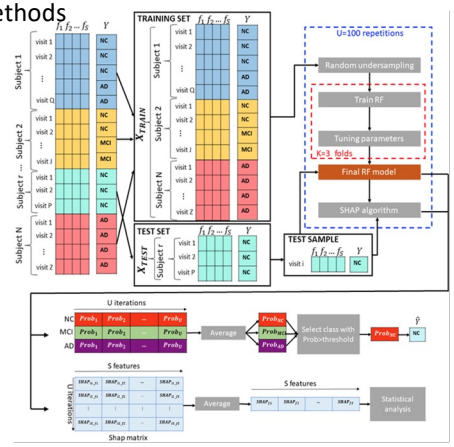
Applications to real-world data samples include ….

Evaluation of the robustness of radiomic features in multiparametric MRI and its impact on predictive value of AI models



Ubaldi L, Saponaro S, Giuliano A, Talamonti C, Retico A. Deriving quantitative information from multiparametric MRI via Radiomics… *Phys Medica* 2023;107:102538 https://doi.org/10.1016/j.ejmp.2023.102538.

Robust implementation of explainable AI methods



Lombardi A, Diacono D, Amoroso N, Biecek P, Monaco A, Bellantuono L, … Tangaro S, Bellotti R. A robust framework to investigate the reliability and stability of explainable artificial intelligence …. *Brain Informatics* 2022; 9:17. https://doi.org/10.1186/s40708-022-00165-5.

WP4

Computing resources and SW repository organization
ReCaS, IBiSCo, INFN-Cloud + local HW resources

WP5

Exploitation of research results and communication
conferences, publications and outreach, collaboration with aifm

next_AIM: stato di avanzamento e obiettivi 2024

Kick-off meeting 2022
https://agenda.infn.it/event/30287/
General Meeting 2023
https://agenda.infn.it/event/34599/

2022		MILESTONES
31 Dec	M1.1	Identification of methodological pitfalls in case of small datasets
31 Dec	M2.1	Identification of explainability requirements for medical applications
31 Dec	M3.1	Identification of data samples for practical use cases and fist tests
30 Jun	M4.1a	Identification of available resources and usage instructions
31 Dec	M4.1b	SW package release instructions
31 Dec	M5.1	~~Workshop organization: "AI methods and applications in Medical Physics"~~
2023		
31 Dec	M1.2	Definition of robust pipelines for efficient model training on small datasets
31 Dec	M2.2	Customization of explainability pipelines to AI models for medical imaging
31 Dec	M3.2	Implementation of robust pipelines and explainability algorithms in at least three different use cases
31 Dec	M4.2	Integration of at least 1 application per site in **next**AIM SW package repository
31 Dec	M5.2	~~Workshop organization: "The right to explanation"~~
2024		
30 Jun	M2.3	Definition of optimal explainability methodology for medical problems
31 Dec	M3.3	Result evaluation for the practical use case and reporting
31 Dec	M4.3	Integration of all analysis pipelines trained for the use cases of WP3 in the **next**AIM SW package repository
31 Dec	M5.3	Submission of at least 1 scientific publication per use case

WS AI@INFN, Bologna 2-3 Maggio 2022
https://agenda.infn.it/event/29907/

State of the art and challenges in AI
Speaker: Daniel Remondini

Deep Learning in Medical Image Analysis
Speaker: Francesca Lizzi

Trustworthy AI in medical applications
Speaker: Angela Lombardi

Workshop "AI methods and applications in Medical Physics"

Non realizzato per mancanza di fondi missione. Abbiamo tenuto a Febbraio un General Meeting di collaborazione su 3 giorni https://agenda.infn.it/event/34599/

31 Dec M2.4 — Workshop "The right to explanation"

Da organizzare nel 2024 come parte di un WS incentrato sull'utilizzo del calcolo di CSN5

next_AIM: stato di avanzamento e obiettivi 2024

Sedi partecipanti													Task	Topic
				FE			LNS		NA		PI		**T1**	Radiomics in Digital Breast Tomosynthesis (DBT)
	BO			FE					NA				**T2**	Super-Resolution in DBT
	BO		CT										**T3**	Radiomics in prostate cancer
	BO		CT										**T4**	Radiomics and DL in tcMRgFUS
	BO					GE	LNS						**T5**	Nuclear Imaging Quantification and Radiomics
BA		CA	CT							PD	PI		**T6**	Connectivity in functional MRI and EEG
		CA	CT	FE	FI	GE		MI			PI	PV	**T7**	Radiomics and Deep Learning analysis of CT and patients' data in COVID-19
								MI			PI	PV	**T8**	Radiomics and ML-segmentation on Facio-Scapulo-Humeral dystrophy (FSHD), lung and liver tumor
BA ?												PV	**T9**	ML on Imaging data of 10B uptake tracks and dose monitoring by Compton cameras
					FI						PI		**T10**	Artificial intelligence for monitoring RT response in soft-tissue sarcomas
				FE						PD			**T11**	Machine Learning techniques for cardiological applications
					FI						PI		**T12**	Application of NLP techniques to clinical notes towards the automated reading of instrumental data

next_AIM: stato di avanzamento e obiettivi 2024

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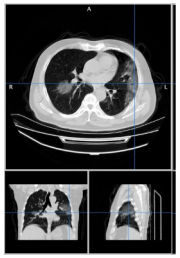
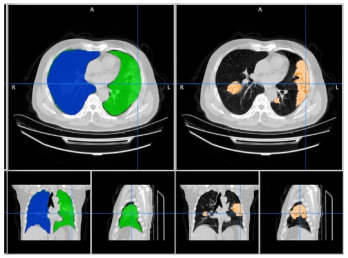


LungQuant

[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.

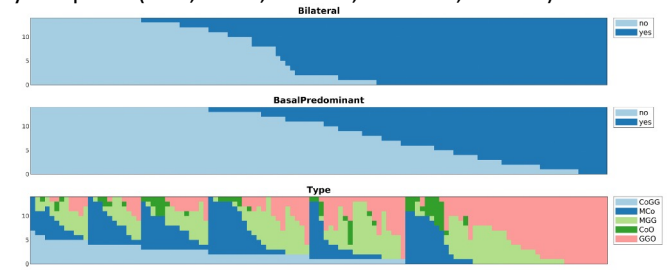


SW output:
- segmented masks
- qualitative parameters to describe the lesions

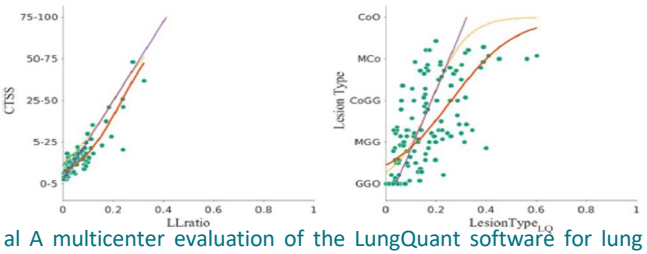
ID	LESION_TYPE_INDEX	BILATERAL_INDEX	BASAL_INDEX
A-0037	0,137	0,447	37
A-0311	0,198	0,041	61
A-0291_0	0,224	0,193	31
A-0327	0,292	0,351	60
	$V_{Consolidation}$ / V_{Lesion}	0: unilateral 1: bilateral	0: basal 100: apical

The validation of the LungQuant software output against the qualitative assessment of 14 radiologists from 5 University Hospitals (Pisa, Pavia, Firenze, Palermo, Milano) has shown:

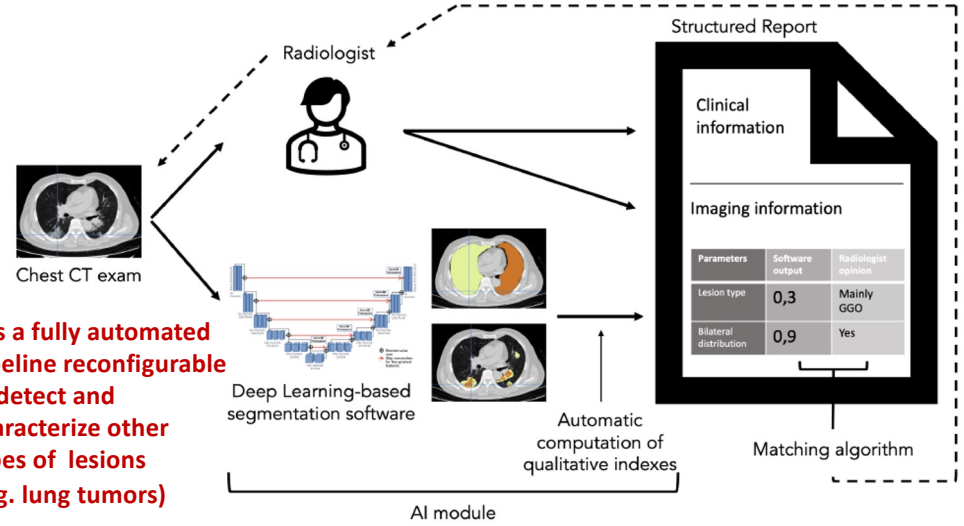
- a poor agreement among the opinions of radiologists



- 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]



It is a fully automated pipeline reconfigurable to detect and characterize other types of lesions (e.g. lung tumors)

[Scapicchio C, et al. Integration of a Deep Learning-Based Module for the Quantification of Imaging Features into the Filling-in Process of the Radiological Structured Report. Int. Jt. Conf. Biomed. Eng. Syst. Technol., SCITEPRESS 2023, p. 663–70. https://doi.org/10.5220/0011921900003414.]

next_AIM: personale @ INFN PI, richieste sui servizi

Fantacci Maria Evelina	UNIPI	50%	
Retico Alessandra	INFN	0%	40%
Arezzini Silvia	INFN	10%	
Ciampa Alberto	INFN	10%	
Mazzoni Enrico	INFN	5%	
Bosco Paolo	Stella Maris	10%	
Laruina Francesco	SNS	40%	
Lizzi Francesca	INFN	0%	50%
Saponaro Sara (SSFM)		100%	
Scapicchio Camilla	INFN	0%	50%
Zafaranchi Arman (PhD in AI)		100%	

3,25 (4,65) FTE totali, con sinergie con progetti PNRR (sia INFN che UNIPI) anche relativamente all'utilizzo del Centro di Calcolo