Challenges of RP in Research and Society Referring to Medical Field
Milan, October 3, 2024

ICRP C3 WP on AI in Imaging and Radiotherapy

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School of Medicine
University of Crete
Greece

ICRP Working Party on AI

Working Party

on radiation protection and AI in medical imaging and radiotherapy

International Commission on Radiological Protection

ICRP Working Party on AI

INTERNATIONAL CO

Draft Terms of Referen

Artificial Intelligence (A

A Task Group

Approved by the Main Co

Background

The integration of artificial intelligence (AI
non-medical settings, has grown significan
potential in enhancing diagnostic accuracy
in various radiological applications. Howeve
concerns regarding safety, ethical consider
context of radiological protection. The imp
and quality assurance in radiological proc
global application of AI in medicine exp
treatment planning, and decision suppo
innovations are properly integrated within

The rationale for the creation of a dedicate
need to ensure that the adoption of AI alig
protection. AI introduces new complexities
and potential biases in clinical decision-m
Furthermore, medical applications of AI,
delivery, present both opportunities and ch
to protect patients, staff, and the public.

ICRP has long been at the forefront of pr
establishment of a Task Group focused
advancements and the unique challenges
transform radiological practices, but wit
introduce risks to patient safety, radiation
include an explanation of the uncertainties

The key areas of focus will include:

1. **Quality assurance and validation of AI systems.** It is essential to develop rigorous quality assurance protocols for AI-powered tools before their implementation in clinical practice. This includes establishing criteria for validating the accuracy, reliability, and safety of AI algorithms used in medical imaging, radiation therapy, and other medical radiological applications.
2. **Radiation dose estimation and optimization.** AI technologies should support dose optimization strategies that minimize patient and operator exposure while maintaining diagnostic quality. The Task Group will provide guidance on how AI can be leveraged to improve radiation protection practices in medical and other settings.
3. **Ethical and legal considerations.** AI systems must adhere to ethical standards, particularly in terms of patient consent, data privacy, and transparency. The Task Group will assess how AI technologies can be aligned with existing ethical frameworks for radiological protection.
4. **AI in non-medical radiological protection.** In non-medical sectors, AI is increasingly being utilized in areas such as environmental monitoring, and nuclear safety. The Task Group will provide recommendations on the use of AI for ensuring the safe handling of radioactive materials and for improving radiation monitoring and emergency response systems.
5. **Training and education for radiological protection personnel.** As AI systems are introduced into radiological protection workflows, there is a need for targeted training programs to ensure that personnel are proficient in the use of these technologies. The Task Group will recommend strategies for integrating AI education into radiological protection training curricula. There is a critical need for communication amongst colleagues and the public in using AI as a tool that will not replace expert workers but will enhance them.

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Key areas of focus: QA of AI tools

nature

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nature > news feature > article

NEWS FEATURE | 21 August 2024

The testing of AI in medicine is a mess. Here’s how it should be done

Hundreds of medical algorithms have been approved on basis of limited clinical data. Scientists are debating who should test these tools and how best to do it.

QA and validation of AI systems in imaging and radiotherapy is needed to ensure

Accuracy

Reliability

Safety

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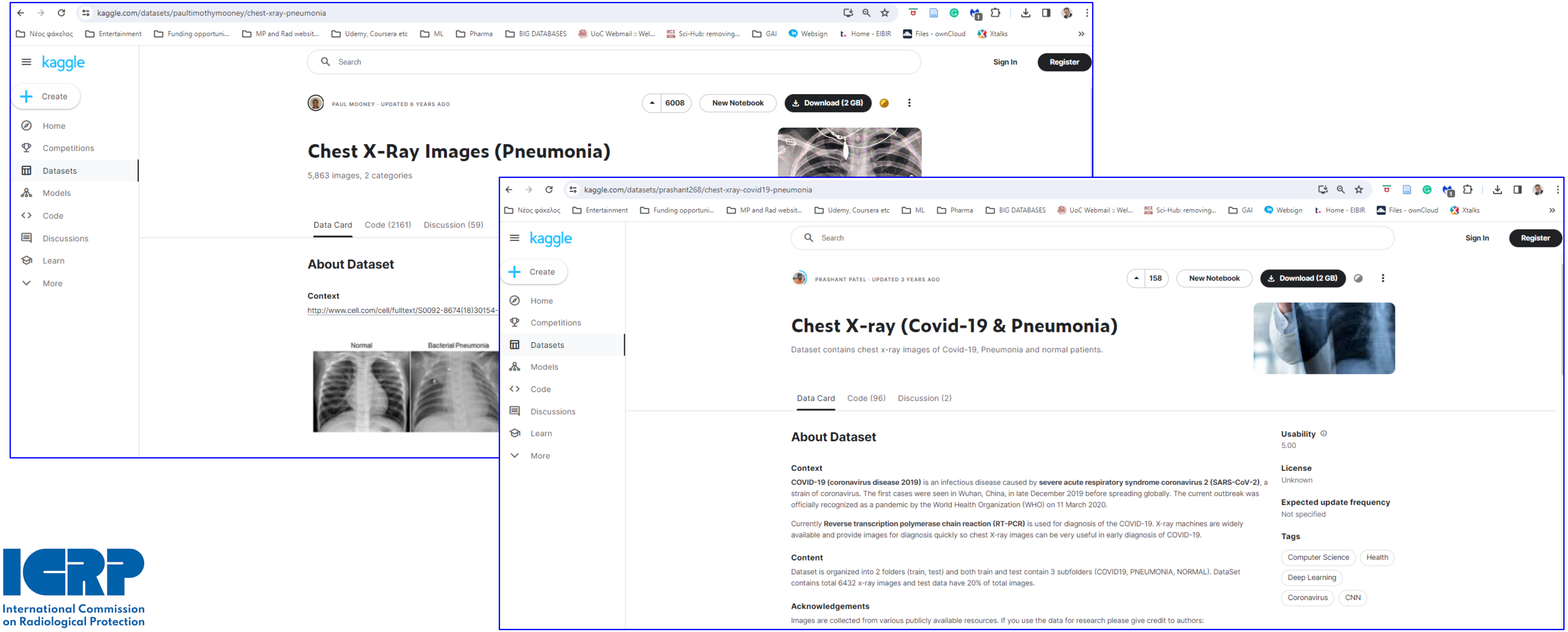
Data quality



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Checklist for AI in medical imaging (CLAIM)

Radiology: Artificial Intelligence

Checklist for Artificial Intelligence in Medical Imaging (CLAIM): 2024 Update

Checklist for Artificial Intelligence in Medical Imaging (CLAIM): 2024 Update

Section/Topic	No.	Item
TITLE/ABSTRACT		
	1	Identification as a study of AI methodology, specifying the category of technology used (eg, deep learning)
ABSTRACT		
	2	Summary of study design, methods, results, and conclusions
INTRODUCTION		
	3	Scientific and/or clinical background, including the intended use and role of the AI approach
	4	Study aims, objectives, and hypotheses
METHODS		
Study Design	5	Prospective or retrospective study
	38	Estimates of diagnostic performance and their precision
	39	Failure analysis of incorrectly classified cases
DISCUSSION		
	40	Study limitations
	41	Implications for practice, including intended use and/or clinical role
OTHER INFORMATION		
	42	Provide a reference to the full study protocol or to additional technical details
	43	Statement about the availability of software, trained model, and/or data
	44	Sources of funding and other support; role of funders

Indicate page and/or line number for each checklist item that is present.

Data	7	Data sources
	8	Inclusion and exclusion criteria
	9	Data preprocessing
	10	Selection of data subsets
	11	De-identification methods
	12	How missing data were handled
	13	Image acquisition protocol
Reference Standard	14	Definition of method(s) used to obtain reference standard
	15	Rationale for choosing the reference standard
	16	Source of reference standard annotations
	17	Annotation of test set
	18	Measures of inter- and intrarater variability of features described by the annotators

CLAIM 2024 Update Panel: Sunhy Abbara, Saif Afat, Udunna C. Anazodo, Anna Andreychenko, Folkert W. Asselbergs, Aldo Badano, Bettina Baessler, Bayarbaatar ...el B. Brismar, Giovanni E. Cacciamani, John A. Carrino, ... Chiang, Tessa S. Cook, Renato Cuocolo, John Dami-... Carlo N. De Cecco, Hesham Elhalawani, Guillermo ...edorov, Benjamin Fine, Adam E. Flanders, Judy Wawira ...er, Safwan S. Halabi, Sven Haller, William Hsu, Krishna ...-Cramer, Apostolos H. Karantanas, Felipe C. Kitamura, ...oh, Elmar Kotter, Elizabeth A. Krupinski, Curtis P. Lan-... ...io Maas, Anant Madabhushi, Lena Maier-Hein, Kostas ...tí, Jaishree Naidoo, Emanuele Neri, Robert Ochs, Niko-... ...s Papathomas, Katja Pinker-Domenig, Daniel Pinto dos ...dros Protonotarios, Mauricio Reyes, Veronica Rotemberg, ...uel Salinas-Miranda, Francesco Sardanelli, Mark E. Sch-... ...enza, Ronnie Sebro, Prateek Sharma, An Tang, Antonios ...er Laak, Peter M. A. van Ooijen, Vasantha K. Venugopal, ... Wood, Carol C. Wu, Greg Zaharchuk, Marc Zins

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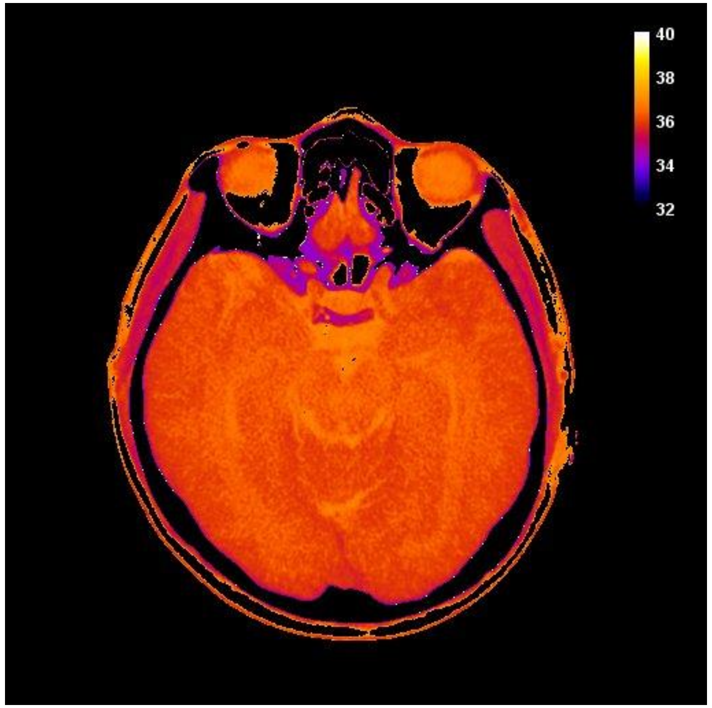
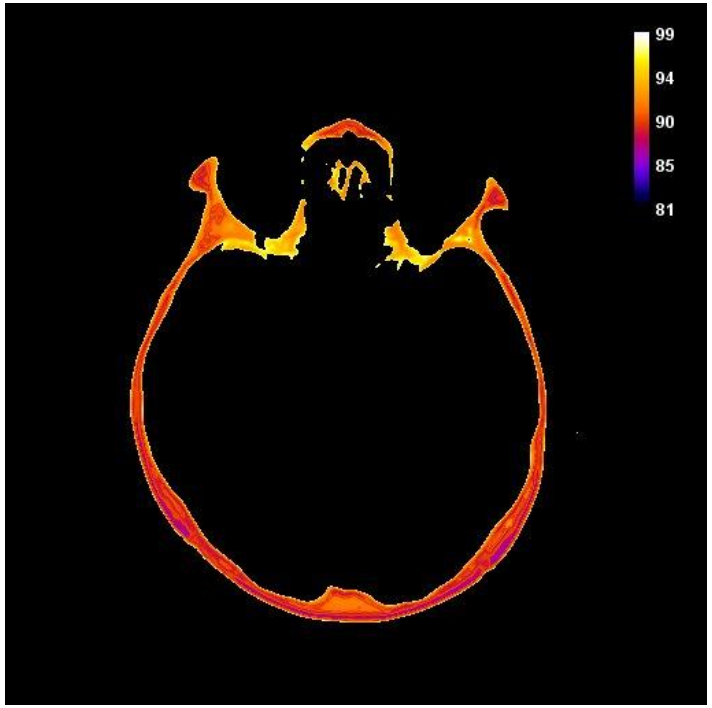
Key areas of focus: Radiation dose estimation & optimization

AI dose image



AI dose image



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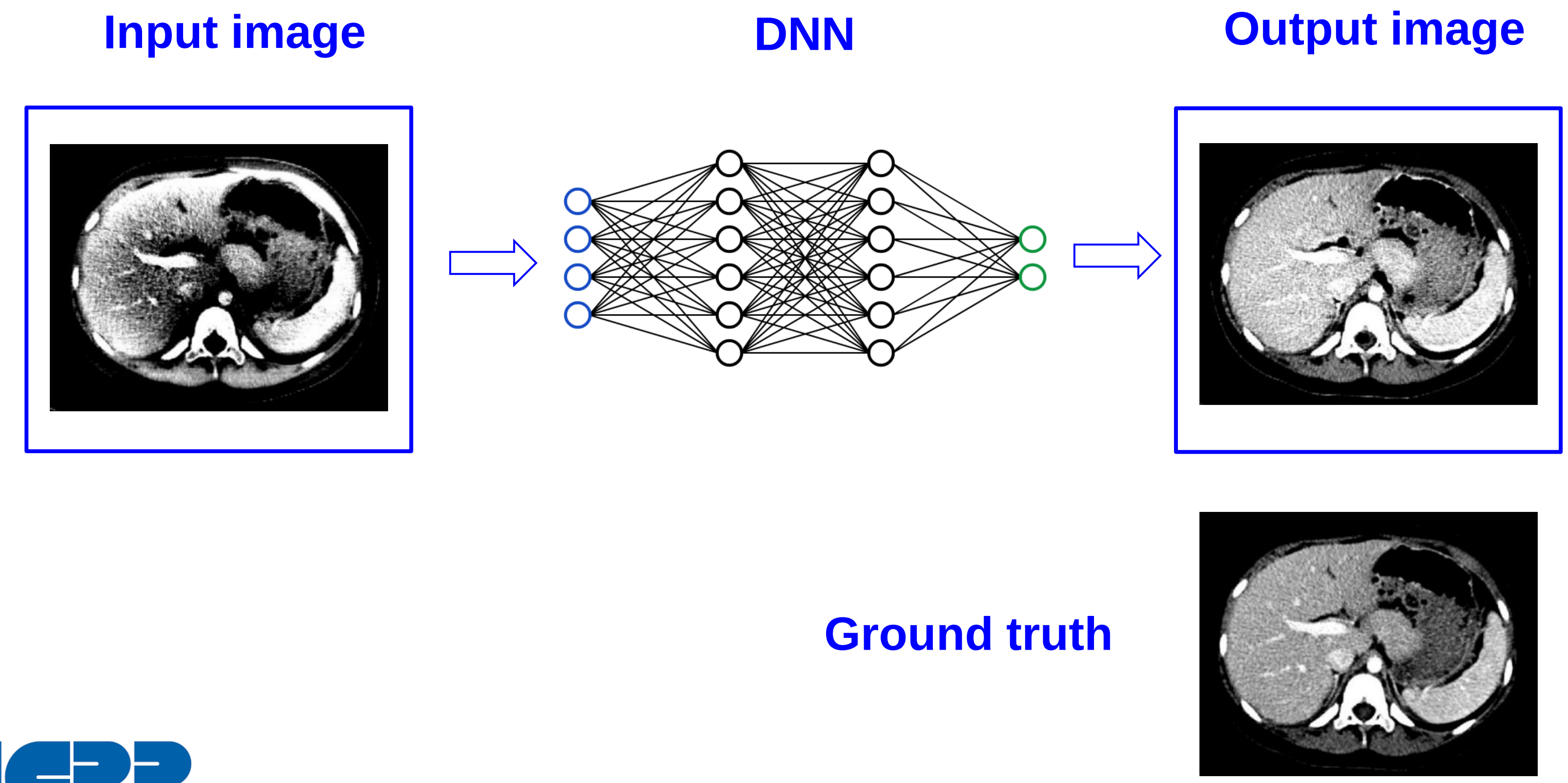
Deep learning CT reconstruction



DNN learns by adjusting various parameters via back-propagation:

- high contrast resolution
- low contrast resolution
- image noise
- image texture
- CT number accuracy
- …………

Image quality improvement

PLOS ONE

RESEARCH ARTICLE

Denoising of pediatric low dose abdominal CT using deep learning based algorithm

Hyoung Suk Park[1], Kiwan Jeon[1], JeongEun Lee[2,3], Sun Kyoung You[2,3]*

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Received: 8 July 2021 | Revised: 28 October 2021 | Accepted: 2 November 2021

DOI: 10.1002/mp.15354

MEDICAL PHYSICS

RESEARCH ARTICLE

A deep learning method for eliminating head motion artifacts in computed tomography

Bin Su[1,¶] | Yuting Wen[2,¶] | Yanyan Liu[1,¶] | Shu Liao[3] | Jianwei Fu[1] | Guotao Quan[1] | Zhenlin Li[2]

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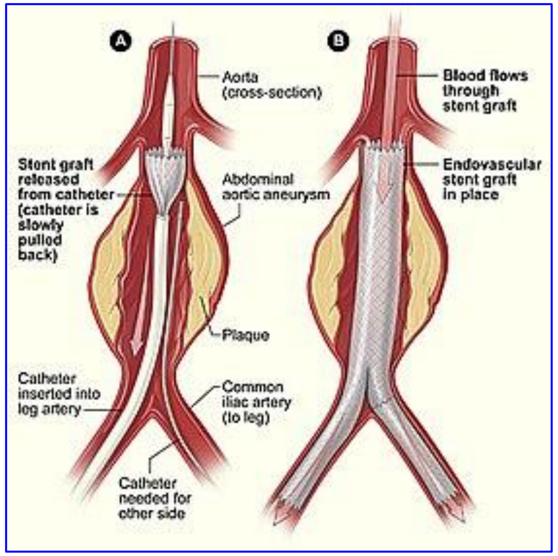
Establishment of DRLs using AI



Endovascular Aneurysm Repair

Physica Medica 114 (2023) 103140

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/ejmp

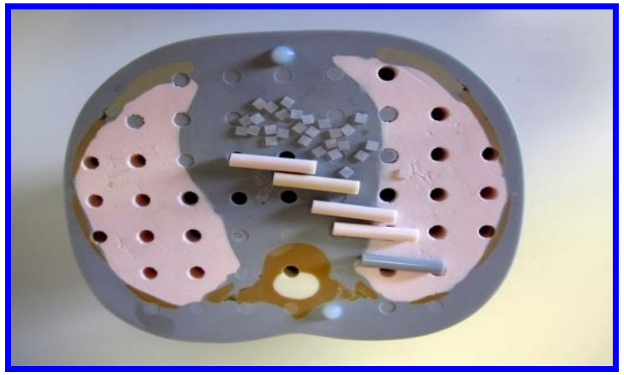
Physica Medica
European Journal of Medical Physics

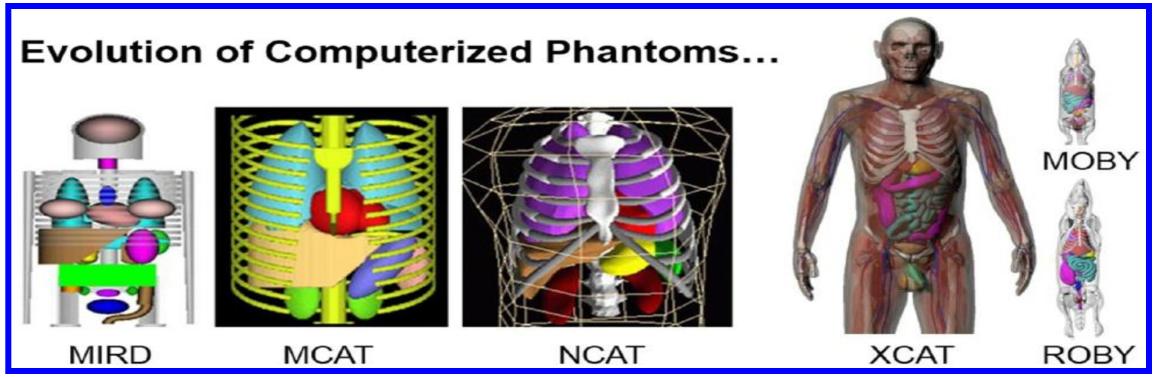
A neural network-enhanced methodology for the rapid establishment of local DRLs in interventional radiology: EVAR as a case example

Eleftherios Tzanis, John Damilakis *

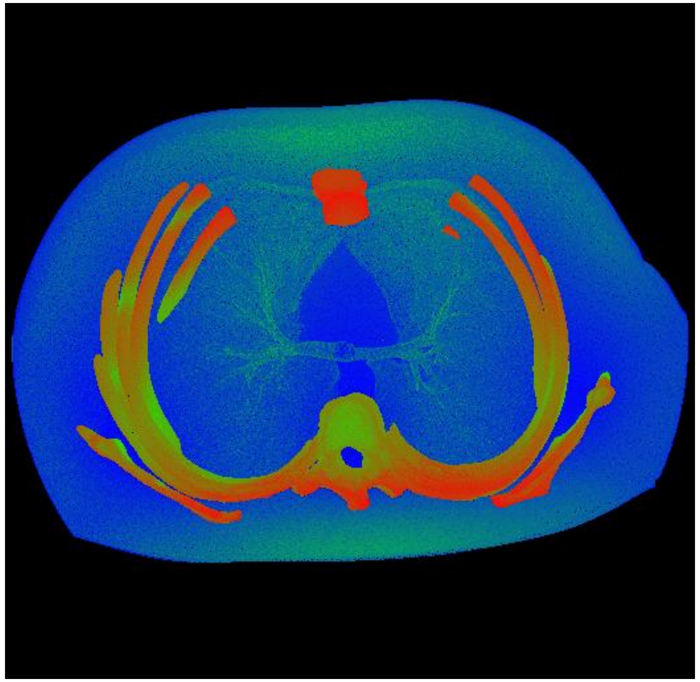
Department of Medical Physics, School of Medicine, University of Crete, P.O. Box 2208, 71003 Heraklion, Crete, Greece

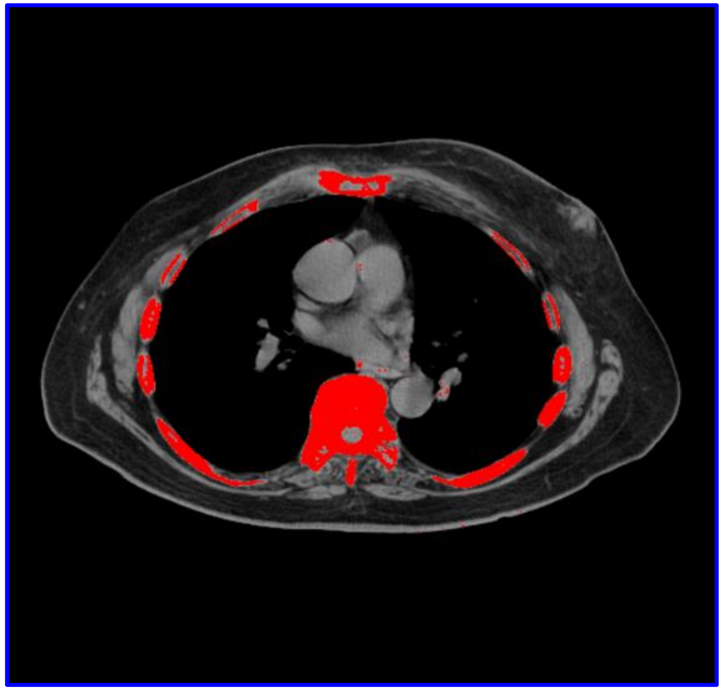
Patient dosimetry: How do we estimate patient doses?

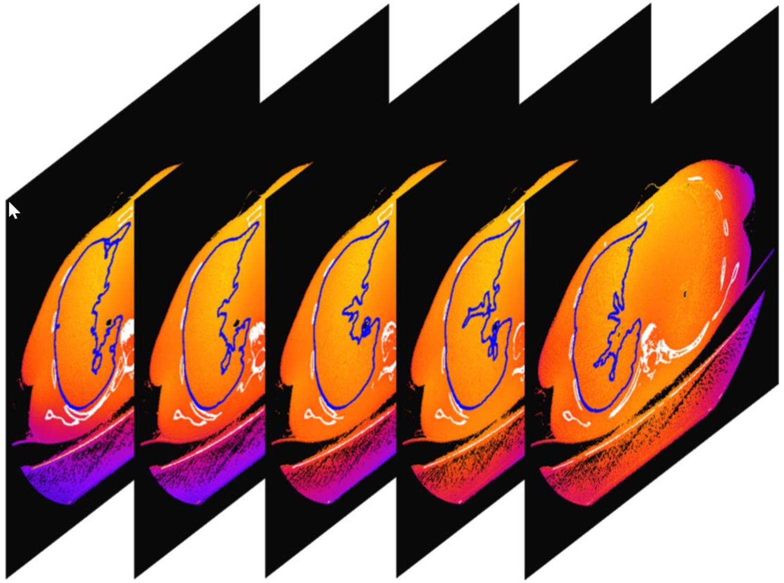




Patient-specific and equipment specific dosimetry







Real time personalized patient dosimetry

We need

- Equipment-specific dosimetry
- True patient-specific dosimetry
- Protocol-specific dosimetry
- Real-time dosimetry

for organ and tissue dose estimation

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Real time personalized dosimetry

Organ dose information will be automatically incorporated into the structured reporting templates so referring physicians will have complete information about patient doses and risks

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AI-powered patient radiation dose prediction

AI-assisted organ dose estimation

European Radiology
https://doi.org/10.1007/s00330-022-08756-w

COMPUTED TOMOGRAPHY

A novel methodology to train and deploy a machine learning model for personalized dose assessment in head CT

Eleftherios Tzanis[1] · John Damilakis[1]

Received: 8 December 2021 / Revised: 28 February 2022 / Accepted: 19 March 2022

Abstract
Objectives To propose a machine learning–based methodology for the creation of radiation dose maps and the prediction of patient-specific organ/tissue doses associated with head CT examinations.
Methods CT data were collected retrospectively for 343 patients who underwent standard head CT examinations. Patient-specific Monte Carlo (MC) simulations were performed to determine the radiation dose distribution to patients' organs/tissues. The collected CT images and the MC–produced dose maps were processed and used for the training of the deep neural network (DNN) model. For the training and validation processes, data from 231 and 112 head CT examinations, respectively, were used. Furthermore, a software tool was developed to produce dose maps from head CT images using the trained DNN model and to automatically calculate the dose to the brain and cranial bones.
Results The mean (range) percentage differences between the doses predicted from the DNN model and those provided by MC simulations for the brain, eye lenses, and cranial bones were 4.5% (0–17.7%), 5.7% (0.2–19.0%), and 5.2% (0.1–18.9%), respectively. The graphical user interface of the software offers a user-friendly way for radiation dose/risk assessment. The implementation of the DNN allowed for a 97% reduction in the computational time needed for the dose estimations.
Conclusions A novel methodology that allows users to develop a DNN model for patient-specific CT dose prediction was developed and implemented. The approach demonstrated herein allows accurate and fast radiation dose estimation for the brain, eye lenses, and cranial bones of patients who undergo head CT examinations and can be used in everyday clinical practice.

European Radiology

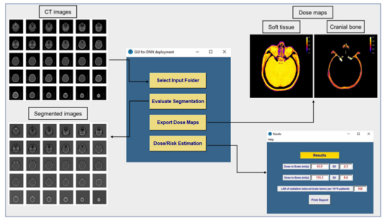
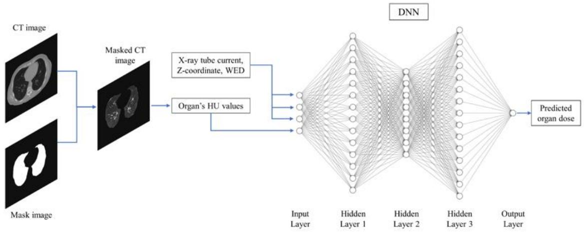


Fig. 3 The graphical user interface. Using the DNN model, the software produces dose maps for each imported CT image. By selecting the "Dose/Risk Estimation" button, the dose to the brain and cranial bones as well as the LAR of radiation-induced cancer risk is automatically calculated

European Radiology, April 2022

An automated ML-based methodology for chest and abdomen CT



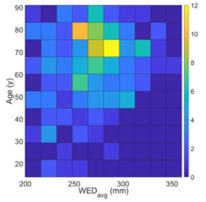
Submitted for publication

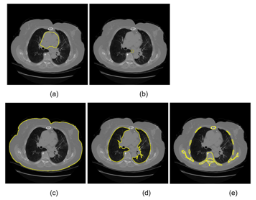
Rapid workflow based on DNN to estimate organ doses from CT

Features: mA, scan length, WED

Ground truth: Patient-specific doses

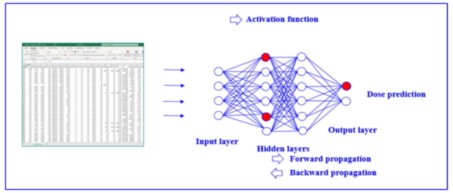
- DNN implemented in MATLAB
- 3 hidden layers with ReLU
- Number of nodes: 100, 200, 50





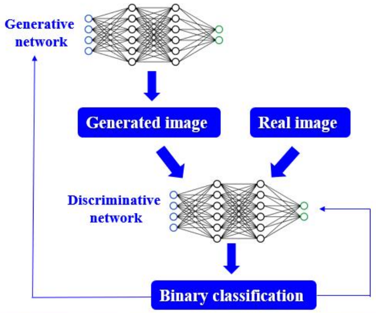
SINFONIA

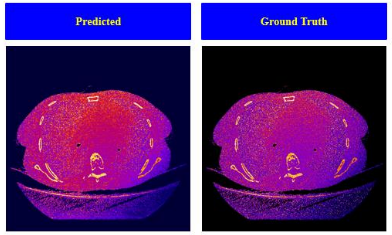
AI-based dose estimation for organs exposed to scattered radiation



How can we train and evaluate a deep learning model for the prediction of liver dose in adult thorax CT examinations?

Generative Adversarial Networks (GANs)





Work in progress

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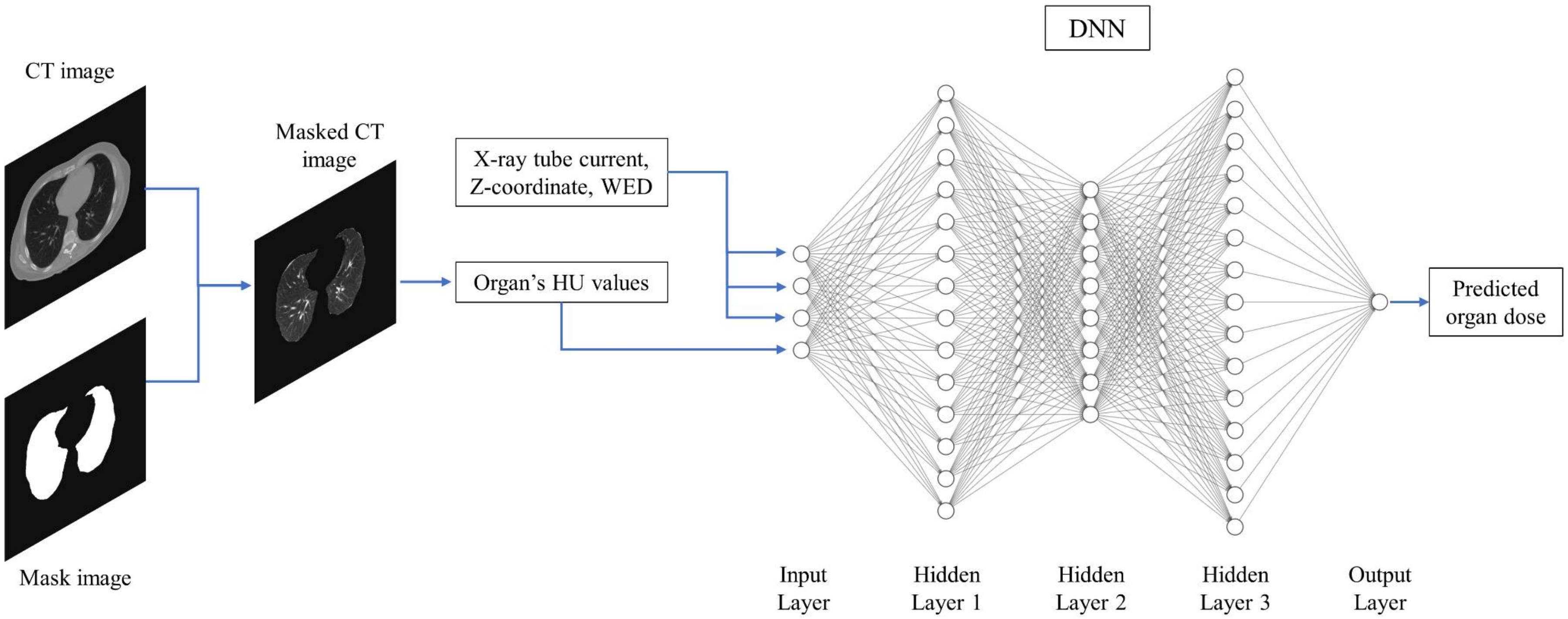
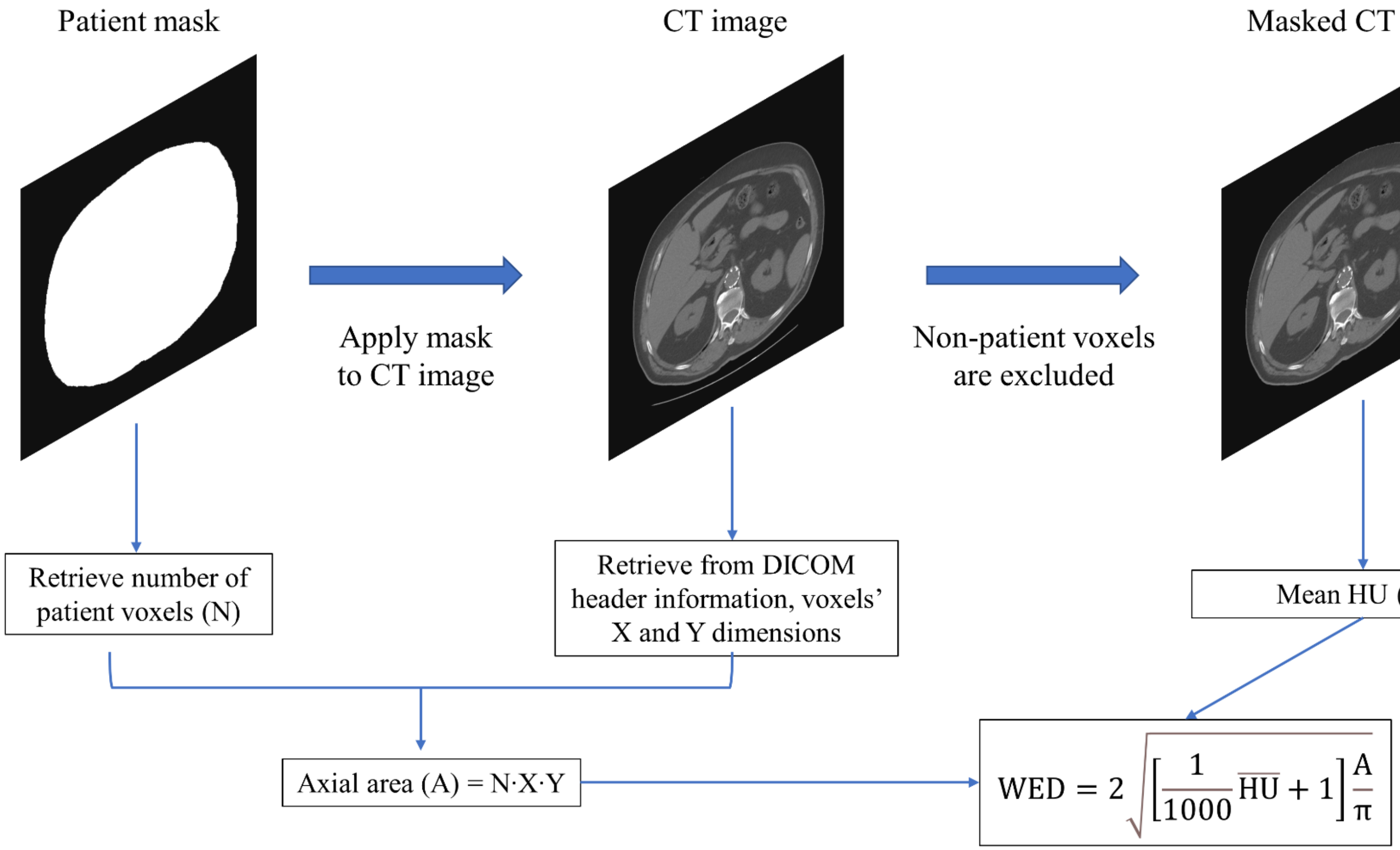
An automated ML-based methodology for CT



Submitted for publication

An automated ML-based methodology for CT



An automated ML-based methodology for CT

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Contents lists available at ScienceDirect

Physica Medica

journal homepage: www.elsevier.com/locate/ejmp

A fully automated machine learning-based methodology for personalized radiation dose assessment in thoracic and abdomen CT

Eleftherios Tzanis, John Stratakis, Marios Myronakis, John Damilakis *

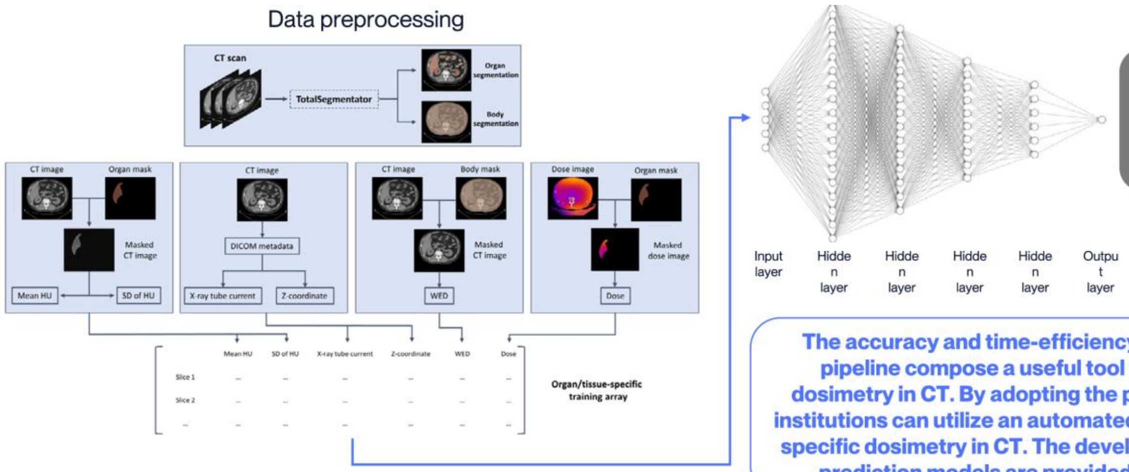
Department of Medical Physics, School of Medicine, University of Crete, P.O. Box 2208, Heraklion, Crete 71003, Greece

Tzanis and Damilakis *European Radiology*
https://doi.org/10.1007/s00330-024-11002-0

EUROPEAN SOCIETY OF RADIOLOGY
European Radiology

COMPUTED TOMOGRAPHY

A machine learning-based pipeline for multi-organ/tissue patient-specific radiation dosimetry in CT



Radiation dose prediction deep neural networks were developed for 30 different organs/tissues

The accuracy and time-efficiency of the developed pipeline compose a useful tool for personalized dosimetry in CT. By adopting the proposed workflow, institutions can utilize an automated pipeline for patient-specific dosimetry in CT. The developed code and dose prediction models are provided as open source.

An automated ML-based methodology for CT

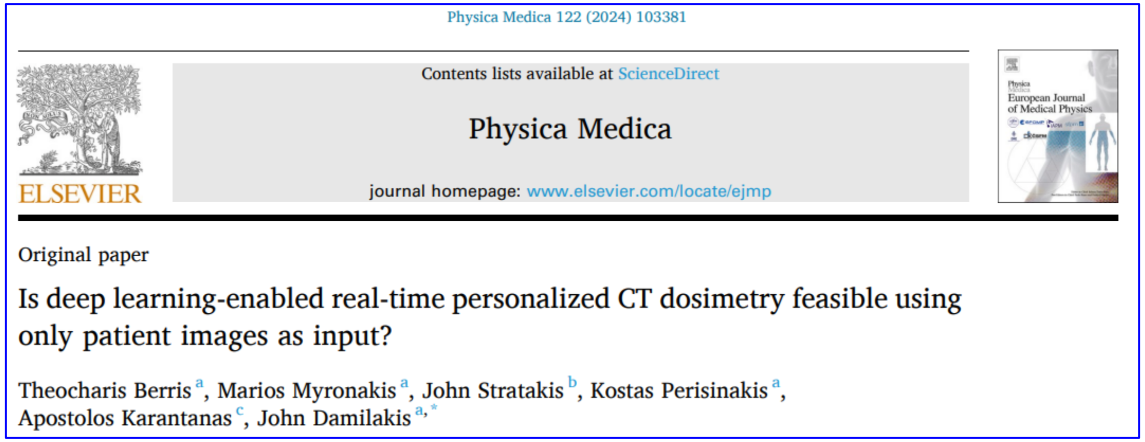
Evaluation of the segmentation models						
Segmentation models	Jaccard score			Dice score		
	Mean	SD	Range	Mean	SD	Range
Lungs	0.92	0.03	0.83-0.95	0.96	0.02	0.91-0.97
Liver	0.93	0.06	0.59-0.97	0.96	0.03	0.74-0.98
Spleen	0.89	0.06	0.58-0.94	0.94	0.04	0.73-0.97
Stomach	0.81	0.12	0.43-0.94	0.89	0.08	0.60-0.97
Kidneys	0.90	0.09	0.60-0.97	0.94	0.05	0.75-0.98
Patient	0.90	0.06	0.76-0.96	0.95	0.03	0.86-0.98
SD = standard deviation						

An automated ML-based methodology for CT

Organ doses estimated with the dose prediction DNN model and MC simulations		
	DNN (mGy)*	MC (mGy)*
Lungs	12.0 (4.1)	12.7 (5.1)
Liver	18.1 (4.6)	18.1 (4.5)
Spleen	18.3 (4.5)	18.7 (4.2)
Stomach	17.7 (4.4)	17.7 (4.1)
Kidneys	18.6 (4.3)	18.4 (4.0)

*Mean values (SD), DNN = deep neural network, MC = Monte Carlo

Generative Adversarial Networks (GANs)



Physica Medica 122 (2024) 103381

Contents lists available at ScienceDirect

Physica Medica

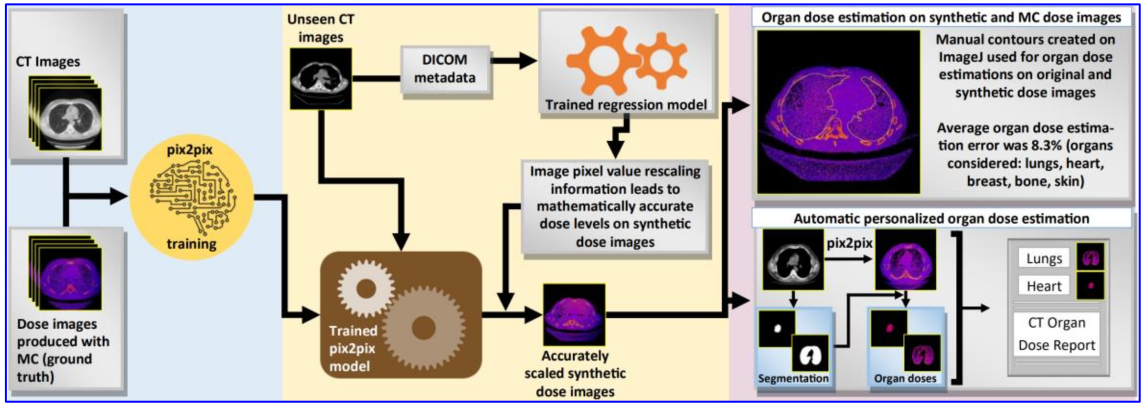
journal homepage: www.elsevier.com/locate/ejmp

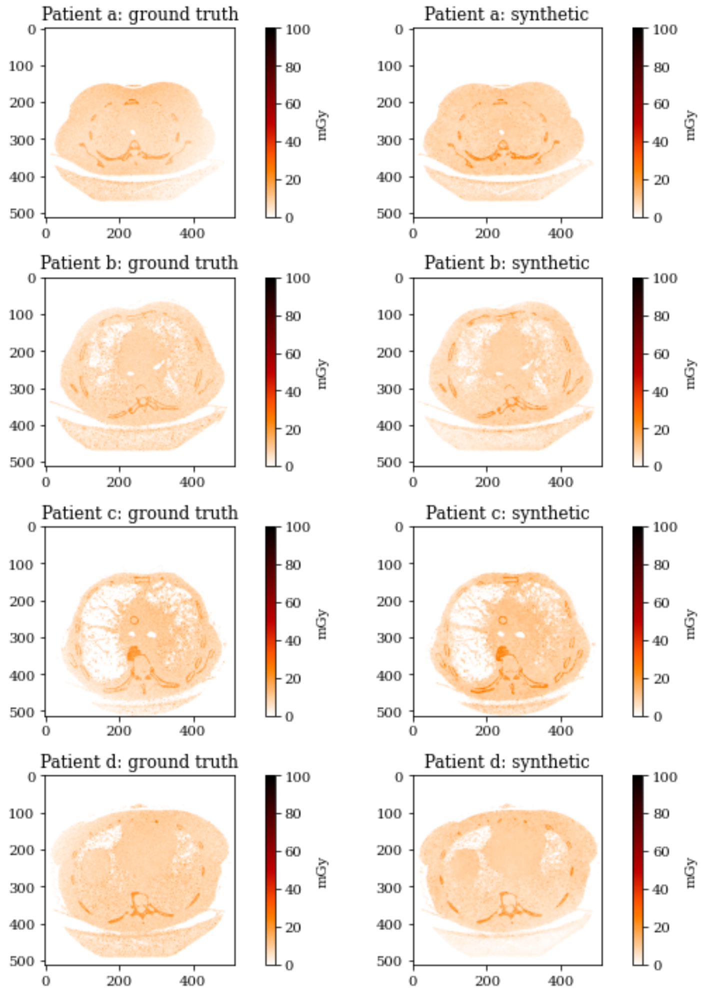
ELSEVIER

Original paper

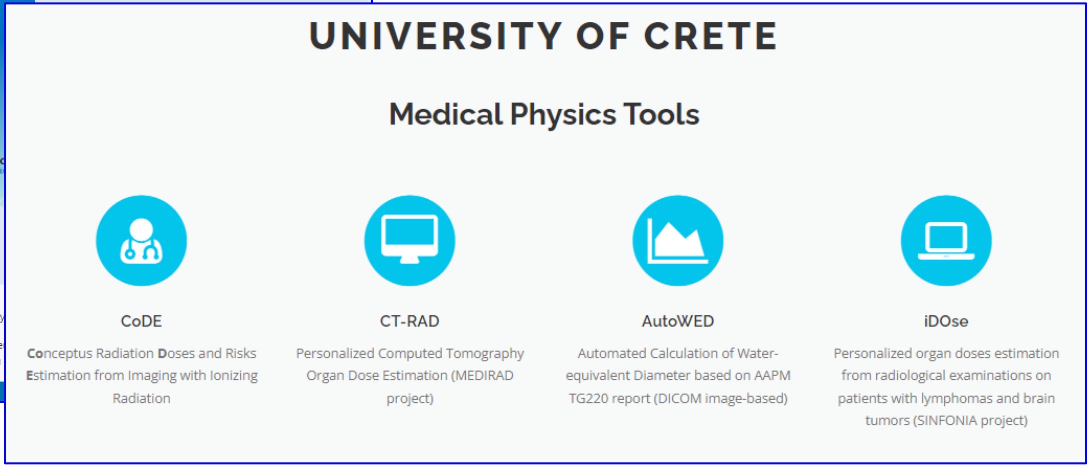
Is deep learning-enabled real-time personalized CT dosimetry feasible using only patient images as input?

Theocharis Berris [a], Marios Myronakis [a], John Stratakis [b], Kostas Perisinakis [a], Apostolos Karantanas [c], John Damilakis [a,*]





i-Dose: a new web-based platform



http://ctdose-iqurad.med.uoc.gr/

Key areas of focus: Ethical & legal considerations

Main ethical and legal considerations

- **Risks for privacy and security**
- **Risks associated with lack of transparency**
- **Risks of biases**
- **Gaps in regulations (e.g., in the field of AI accountability/liability)**
- **Gaps in certification of AI products**

International Commission on Radiological Protection

Key areas of focus: E&T for radiological protection personnel

Key strategies to integrate AI education into RP curricula

- **AI-powered virtual assistants**
- **Hands-on simulations**
- **Modular training ptograms**
- **Collaborative learning with AI experts**

AI presents unique challenges and amazing opportunities

Challenges/Issues

- Bias and discrimination
- Lack of transparency
- Dependence
- Lack of regulation
- Security and privacy concerns

Technical solutions and tools (examples)

- Federated Learning, Swarm learning
- Generative AI
- OCR DL
- Explainable AI
- Low code/no code AI

Benefits

- Improved, fast workflows
- Available at all times
- Reduction of human error
- Reduction of cost
- Informed patient care

Thank you!