

CHIST-ERA Projects Seminar 2022

Topic XAI

Panagiotis Papadimitroulas
BIOEMTECH – Athens, Greece

INFORM:
Interpretability of Deep Neural Networks for Radiomics

March 29, 2022



Programme co-funded by the
EUROPEAN UNION

General Info

INFORM:

Interpretability of Deep Neural Networks for Radiomics

- Topic: XAI
- Project ID: CHIST-ERA-19-XAI-007
- Starting date: March 2021
- Duration: 36 months
- Consortium: 3 Partners (BIOEMTECH - UW - LaTIM)

Scientific Background (I)

INFORM falls within the field of Medical Physics and Bioinformatics

Goal: to improve clinical diagnosis and decision making through extraction of engineered image features (intensity, shape, textures) called Radiomics.

Radiomics is defined as the high-throughput extraction of “engineered/handcrafted” features from medical images

- Deep Neural Networks (DNNs) broad implementation in classification, denoising, segmentation medical image synthesis
- Limited adaptation in Radiomics

Scientific Background (II)

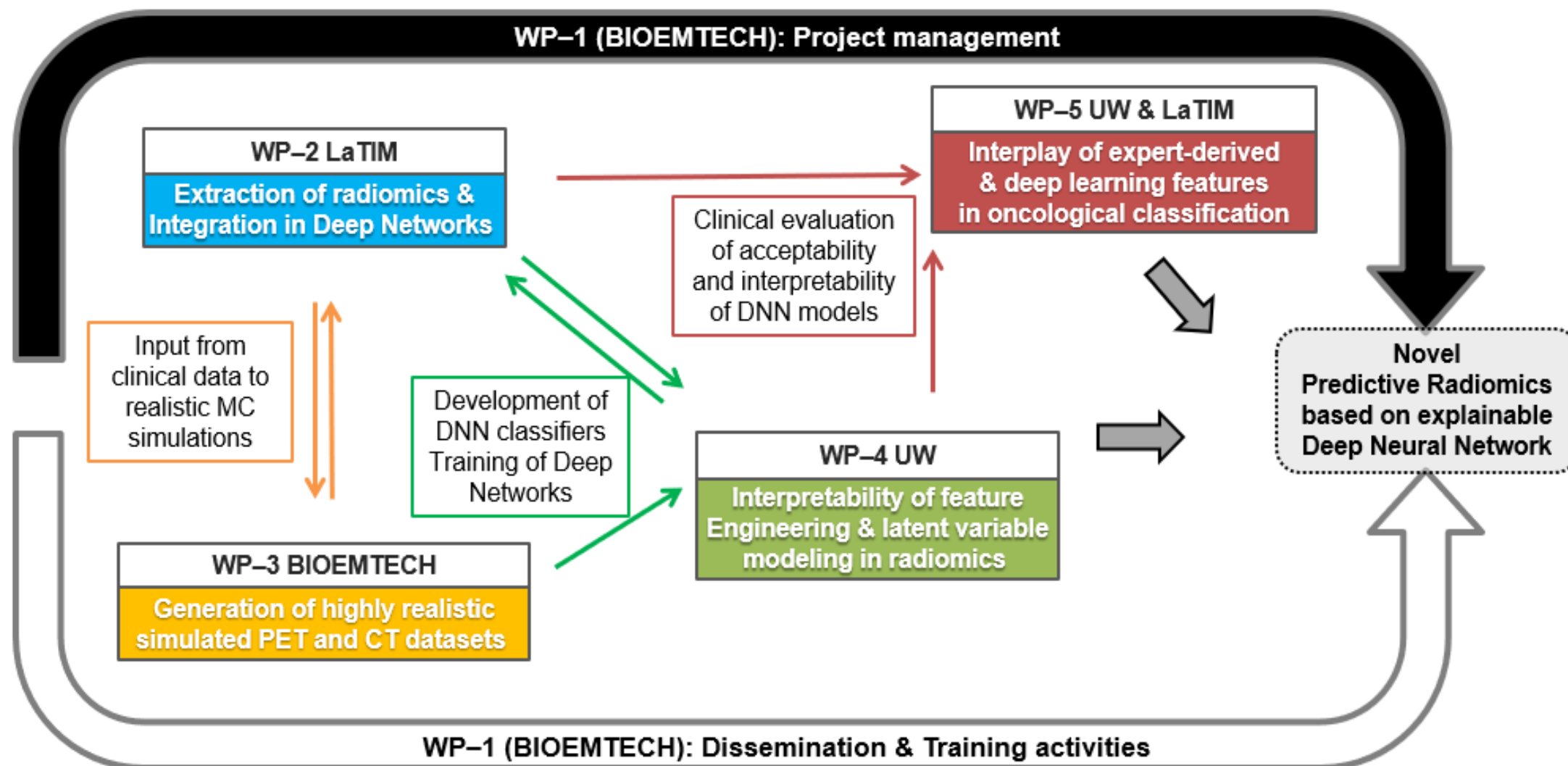
Background: Potential of DNNs to improve oncological classification performances in radiomics.

Lack of interpretability of such models prevents their broad utilization, performance and generalizability.

INFORM's approach (investigate XAI):

- Build high performance DNN-based classifiers
- Develop novel interpretability techniques for radiomics

Methodology



Key challenges

- Alternative therapeutic strategies based on AI prediction models.
- Crucial to integrate data from several sources (clinical, imaging, dosimetry, genetics, toxicity, etc) in order to improve predictive ability.
- Challenging for end-users to interpret multiparametric radiomic models
- Acceptance and implementation of DNN-based AI systems in radiomics and other medical applications are difficult to predict.

The INFORM project aims to develop paths away from unexplainable black box algorithms towards explainable grey/white box models for radiomics.

Potential Impact

- Optimize patient management and clinical treatment strategies by developing novel methods to facilitate decision-aid systems.
- Play a major role in facilitating the acceptability of DNN decision-aid models in medical imaging and oncology.
- The successful implementation of this project will have a large and prolonged impact both in the medical and the computing field

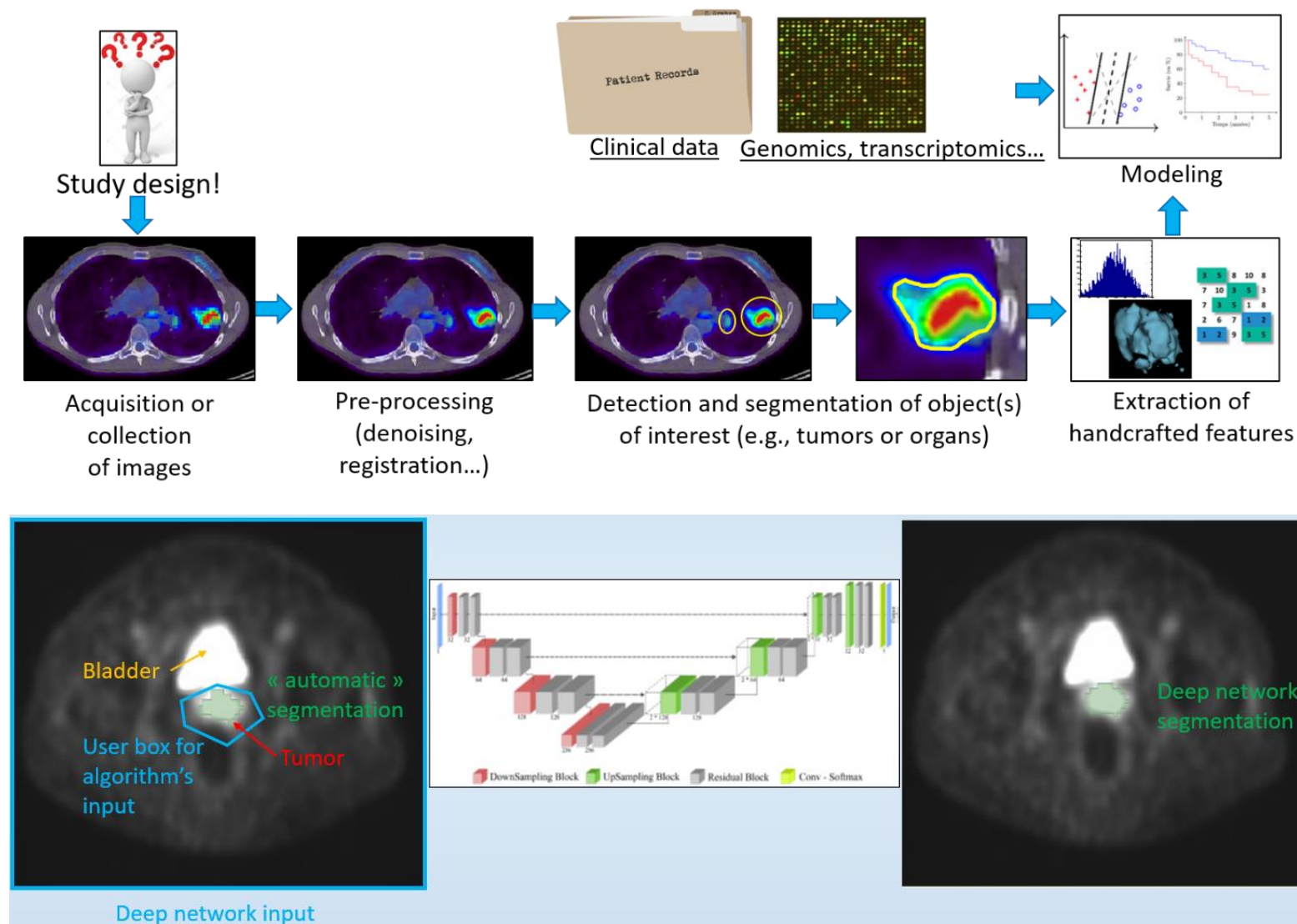
Potential Impact

Multilevel impact is expected in different sections
science, economy, society

- i. Novel computational tools potentially translated to clinical practice.
- ii. Knowledge transfer to the team members and to the broader society.
- iii. Innovative results in the fields of Medical Physics, Bioinformatics, AI.
- iv. Attractive working environment for young Researchers.
- v. Preliminary market analysis by the involved SME to investigate potentiality of a software tool for support in clinical practice.

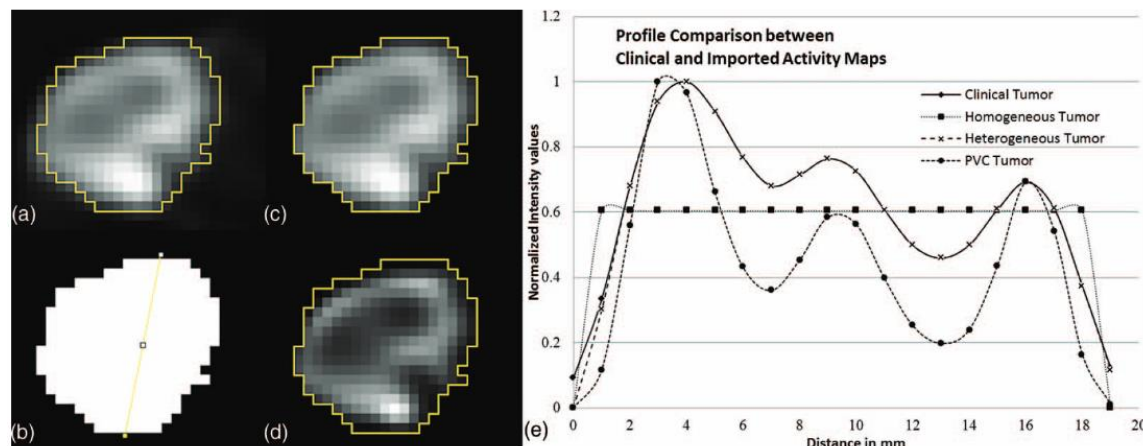
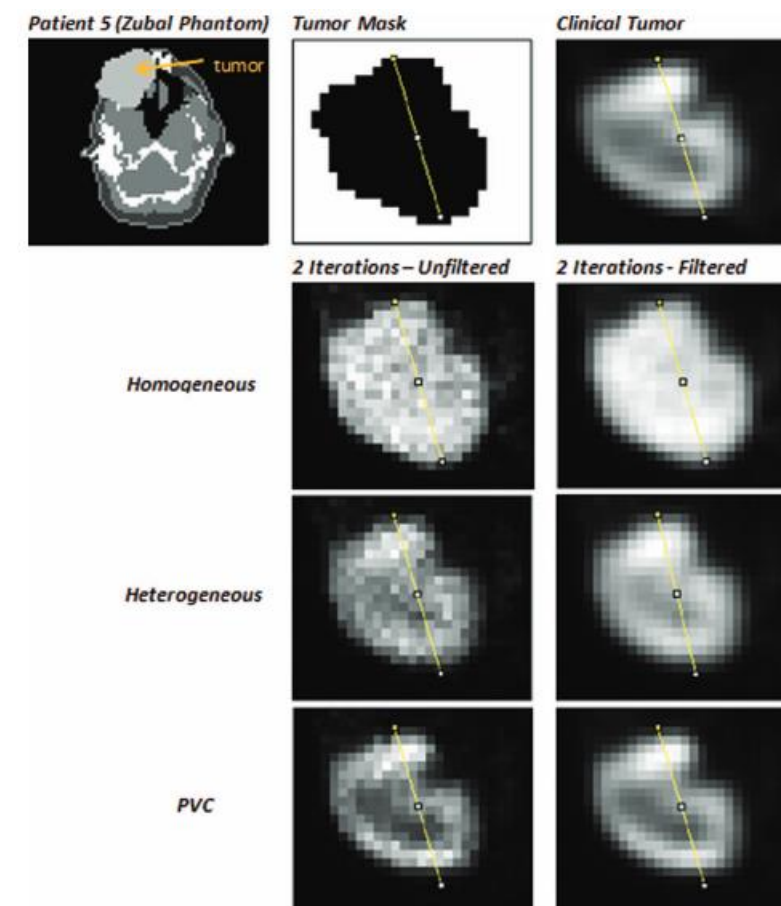
Results (I) Radiomics extraction

- ✓ Dataset from MICCAI challenge HECKTOR-2021 shared with the consortium, by LaTIM.
- ✓ Currently it includes ~325 patients with PET/CT imaging data.
- ✓ Pre-processing procedures have been standardized (deconvolution, denoising, registration, harmonization) before applying radiomics extraction.
- ✓ Deep networks are used for tumor semi-auto segmentation.



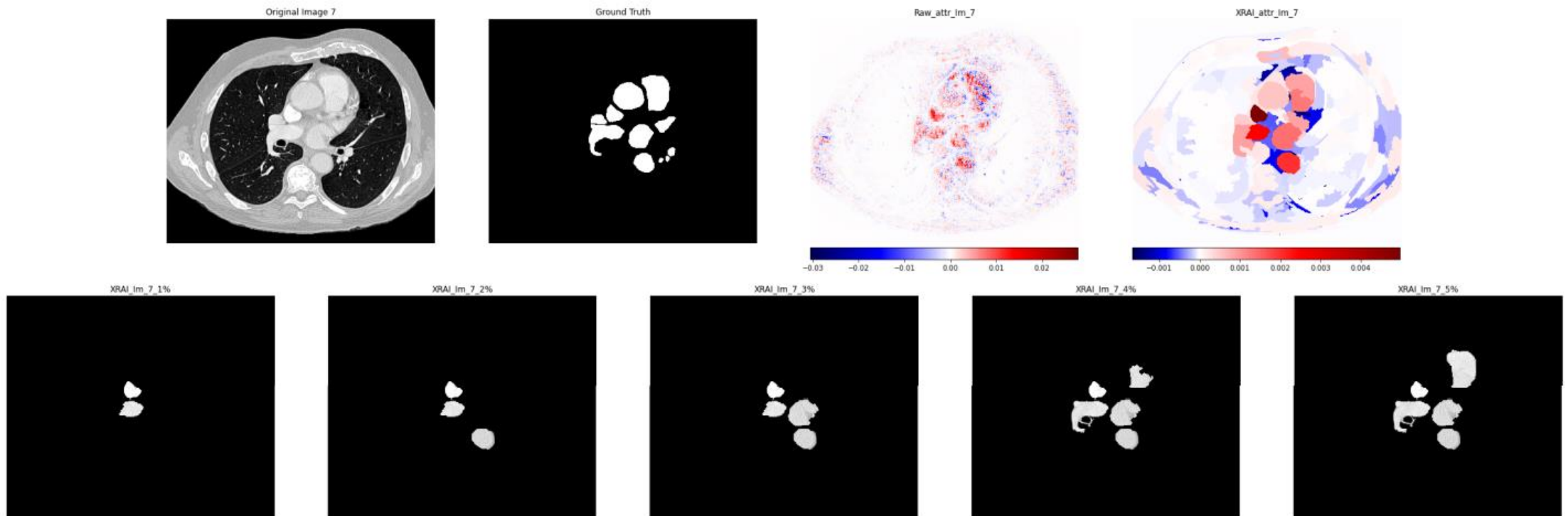
Results (II) MC simulations

- ✓ Monte Carlo simulations provide the ground truth for studying imaging parameters in Medical Imaging.
- ✓ GATE is a well validated tool based on Geant4 code.
- ✓ A model of a validated clinical PET scanner was used to create “synthetic” realistic imaging data (digital patients).
- ✓ XCAT & Zubal computational anthropomorphic models used, to simulate different oncological PET scans.
- ✓ Methodology standardized to simulate tumor heterogeneity.
- ✓ High accuracy achieved in the simulated data.



Results (III) DL classifiers for CT

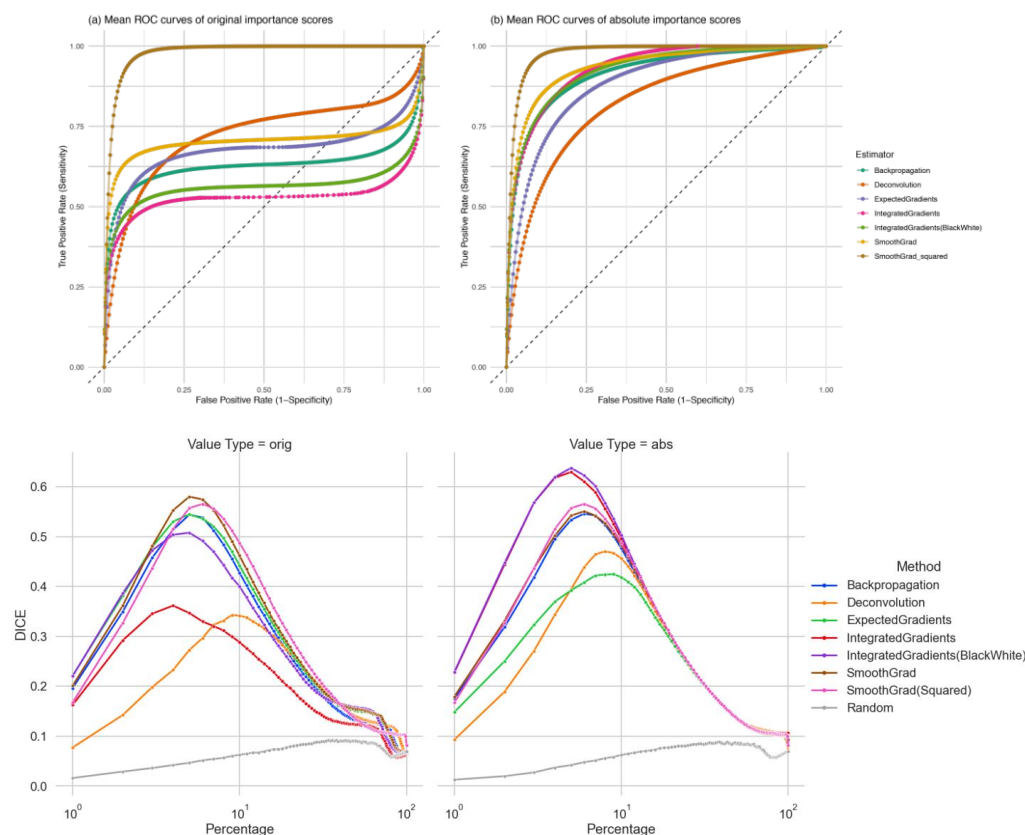
- ✓ Main goal to interpret and explain the prediction of NNs.
- ✓ Investigation on how diverse importance estimators (saliency maps) perform in classifying CT scans, using 3 distinct evaluation metrics.
- ✓ The 3 metrics evaluate different aspects of interpretability.
- ✓ Importance estimators are focused on pixel-level methods



Results (III) DL classifiers for CT

- ✓ Results of the fidelity metric with and without application of absolute value
- ✓ Results of Concordance between importance scores and segmentation, measured by receiver operating characteristic (ROC) curves
- ✓ XRAI-based region-wise overlap comparison (Dice Similarity Coefficients against displayed percentage of most salient regions in segmented heatmaps)

Estimator	$F \times 10$ (Original)	$F \times 10$ (Absolute)
SmoothGradSQ	6.2	6.2
SmoothGrad	3.4	6.1
IntGradBW	0.0	5.7
ExpectedGrad	3.6	5.6
Backpropagation	0.1	4.9
Deconvolution	2.6	4.4
IntGrad	0.0	4.2
Random	0.0	0.0



Results (IV) Dissemination

- ✓ 1 review publication in Physica Medica Journal
- ✓ 1 submission in EXTRAAMAS 2022 on DL classifiers on CT scans (Brocki and Marchadour et al.)
- ✓ Logo
- ✓ Poster
- ✓ Social media presence
- ✓ Website (www.inform-project.eu)



ABOUT ▾

NEWS

DISSEMINATION

CONTACT

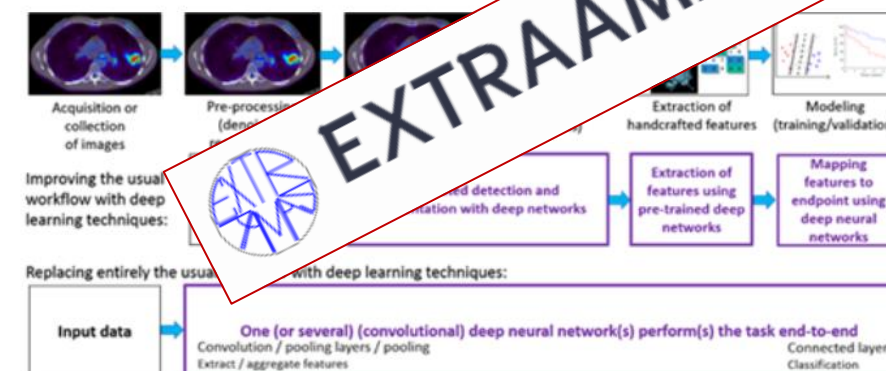


INFORM

Background



Radiomics is defined as the high-throughput extraction of “engineered/handcrafted” features from medical images. It has the potential to provide a quantitative signature of tumors’ characteristics that cannot be appreciated visually and has shown promising results in identifying tumor subtypes and in predicting outcome by relying on ML methods to exploit radiomic features in combination with clinical or other variables to build predictive models. The use of DL and specifically convolutional neural networks (CNNs) in computer vision have led to state-of-the-art results in filtering, segmentation, classification, and synthesis (image-to-image translation) including for medical images. However, the attempts for predictive modeling in radiomics were met with limited success given the limited amount of available data for training compared to other applications. The current research trend is to rely on DL as it allows a higher level of automation compared to the traditional radiomics workflow before facilitate its clinical translation.



Sustainability / Exploitation

- ✓ Peer reviewed journal publications
- ✓ Participation in public national/international events
- ✓ Organisation of a multistakeholder workshop to bridge AI researchers and stakeholders.
- ✓ 1 hands-on training school
- ✓ Exploitation strategy plan
- ✓ Aim at new collaborations / research proposals



Consortium members



Panagiotis Papadimitroulas (PhD, Medical Physicist)

panpap@bioemtech.com

GSRI (National Funding Organisation)

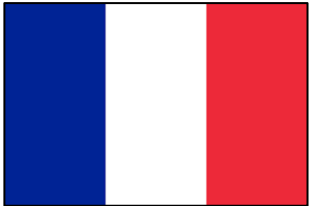
- Coordination
- MC simulations / Synthetic data
- Medical Image Processing / Evaluation of DNN models
- Dissemination / Exploitation / Training



Consortium members



Laboratoire de Traitement
de l'Information Médicale
Laboratory of Medical
Information Processing



Mathieu Hatt (PhD, Medical Informatics)
mathieu.hatt@univ-brest.fr

ANR (National Funding Organisation)

- Medical Image Processing & Analysis
- Medical Data Collection
- Expert in Radiomics / Multimodal Imaging
- Image Synthesis – GAN and ML techniques



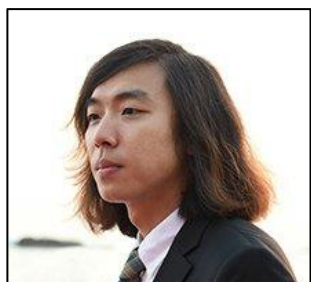
Consortium members

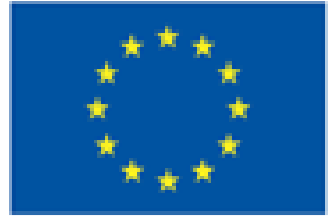


Neo Christopher Chung (Assistant Professor in Computer Science)
nchchung@gmail.com

NCN (National Funding Organisation)

- AI expert (DL / ML)
- Expertise in High-dimensional Statistical Models
- Development of DNN classifiers and Saliency Maps
- Biomedical Engineering & Computational Biology background





Programme co-funded by the
EUROPEAN UNION



Thank you!