AI in modern imaging

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Introduction

Original image

Tumor

+

Noise

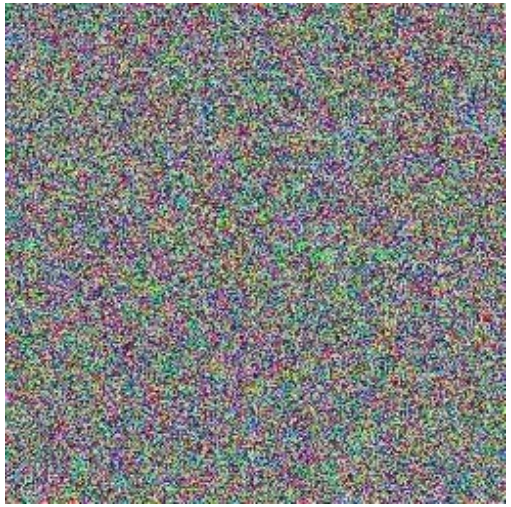

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Image with noise

Healthy

AI models are very sensitive to small variabilities in the input image

Introduction

Requirements to develop a robust AI model:

Introduction

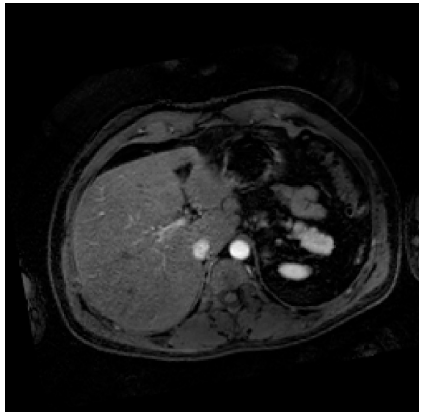
Requirements to develop a robust AI model:

1. **Heterogeneity in the database:**
    - Male and female
    - Different ages
    - Different nationalities
    - Multi-centric
    - Different scanners
    - Different acquisition protocols
    - …

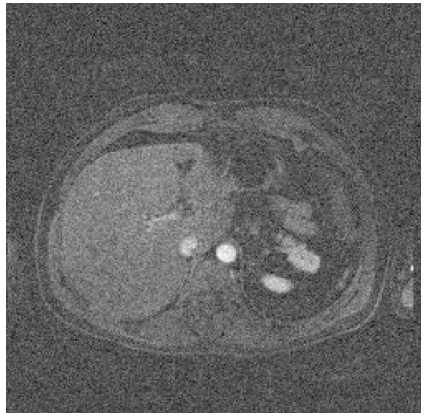
Introduction

Requirements to develop a robust AI model:

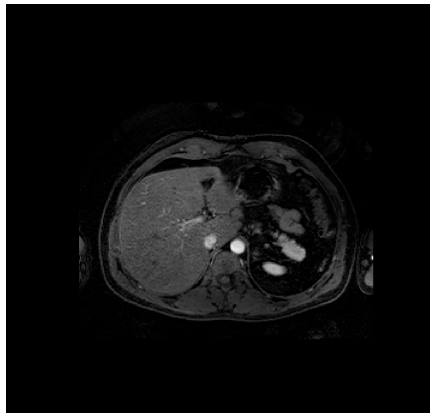
1. Heterogeneity in the database
2. **Data augmentation techniques**



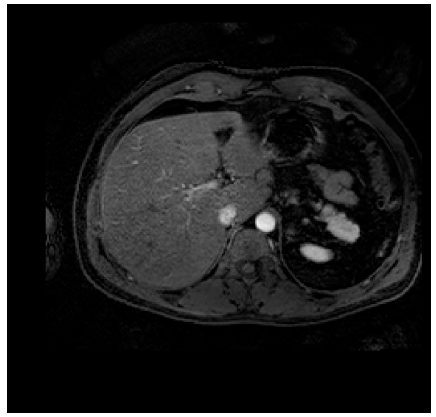
Rotations



Noise



Zoom



Translations

...

Introduction

Requirements to develop a robust AI model:

1. Heterogeneity in the database
2. Data augmentation techniques
3. **External validation**

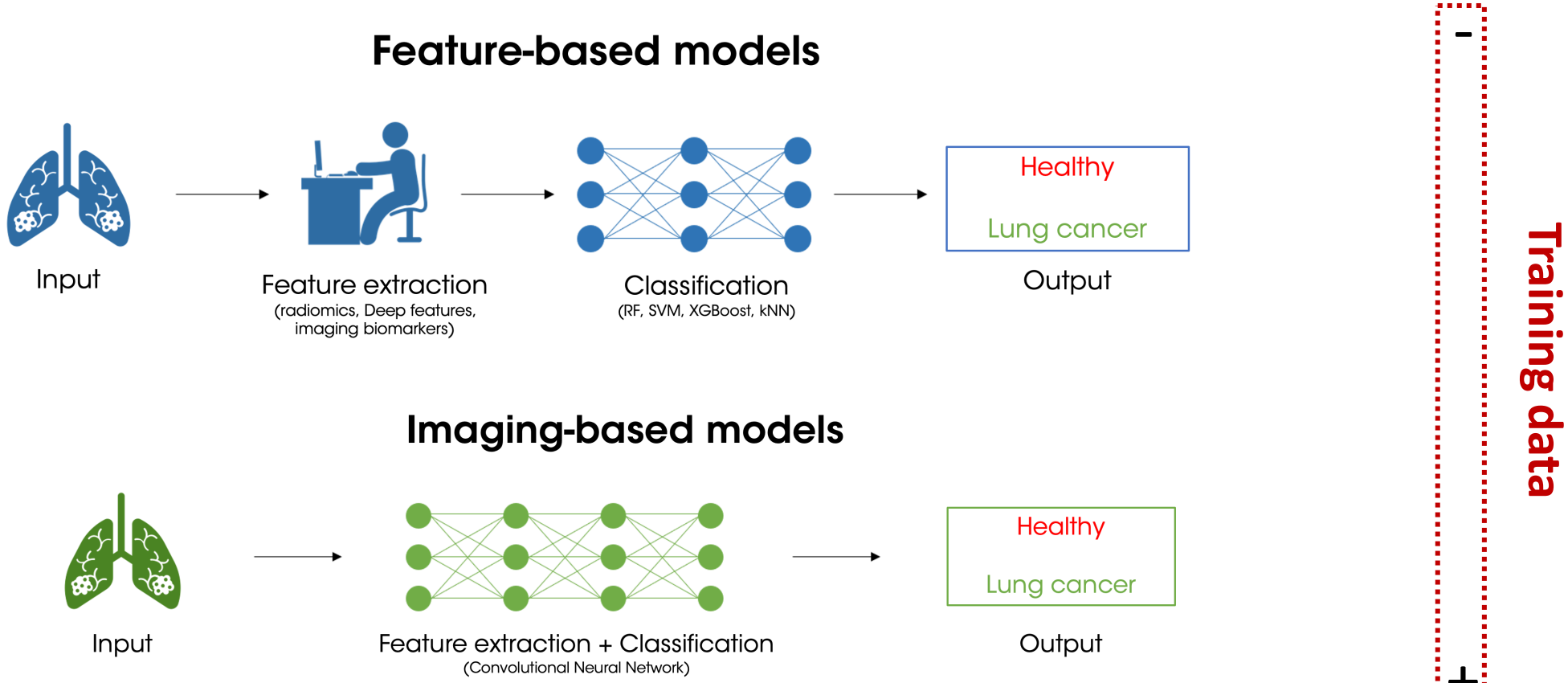
Design Characteristics of Studies Reporting the Performance of Artificial Intelligence Algorithms for Diagnostic Analysis of Medical Images: Results from Recently Published Papers

Dong Wook Kim, MD[1]*, Hye Young Jang, MD[2]*, Kyung Won Kim, MD, PhD[2], Youngbin Shin, MS[2], Seong Ho Park, MD, PhD[2]

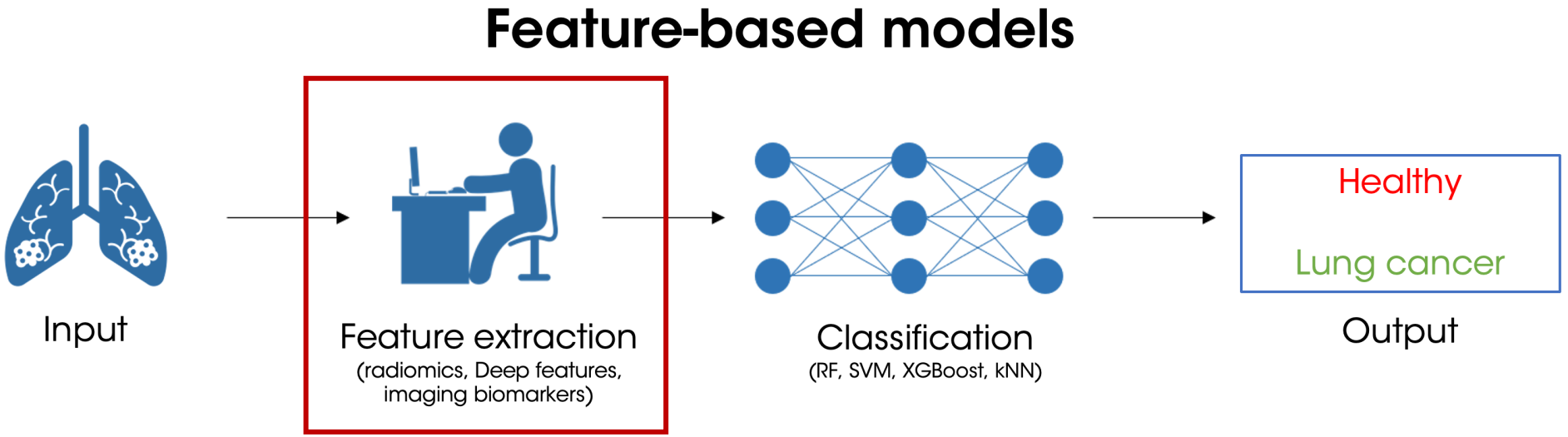
[1]Department of Radiology, Taean-gun Health Center and County Hospital, Taean-gun, Korea; [2]Department of Radiology and Research Institute of Radiology, University of Ulsan College of Medicine, Asan Medical Center, Seoul, Korea

Results: Of 516 eligible published studies, only 6% (31 studies) performed external validation. None of the 31 studies adopted all three design features: diagnostic cohort design, the inclusion of multiple institutions, and prospective data collection for external validation. No significant difference was found between medical and non-medical journals.

AI models development strategies

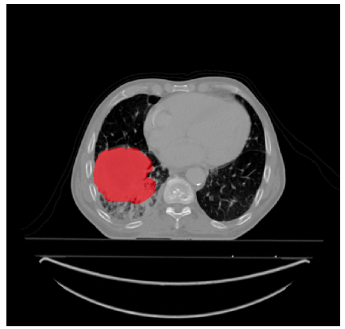


AI models development strategies

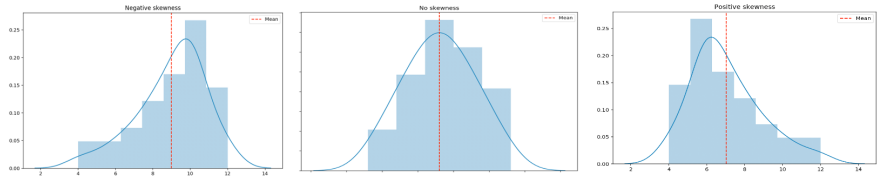


AI models development strategies

Feature-based models. Radiomics features



1. First order: Distribution of individual voxel values



2. Second order: Statistical inter-relationships between neighboring voxels

GLCM GLRLM GLSZM GLDM NGTDM

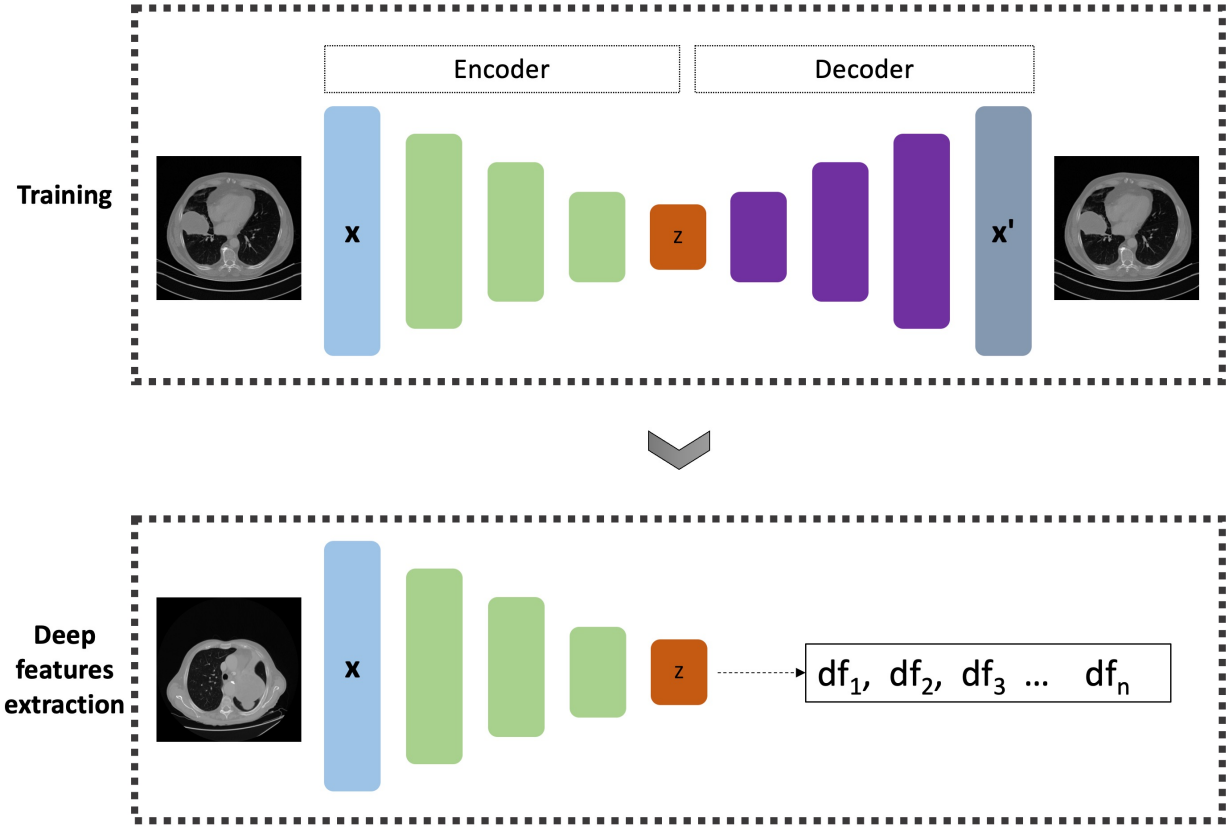
3. Shape: Geometric properties of the delineated ROI

4. Higher order features

Square, exponential, logarithm, wavelet, LoG

AI models development strategies

Feature-based models. Deep features



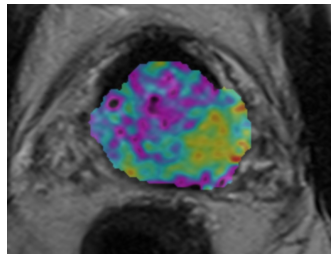
AI models development strategies

Feature-based models. Imaging biomarkers

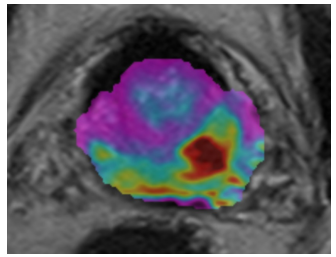
MRI

CT

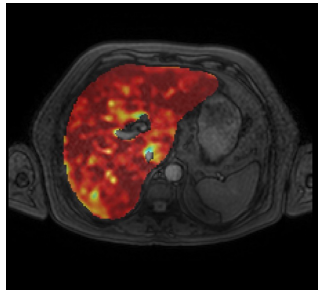
PET



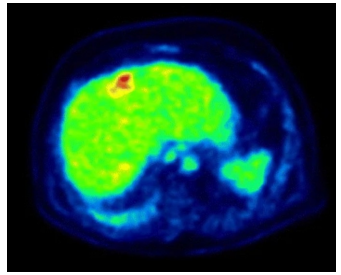
ADC



K^{trans}



PDFF



SUV

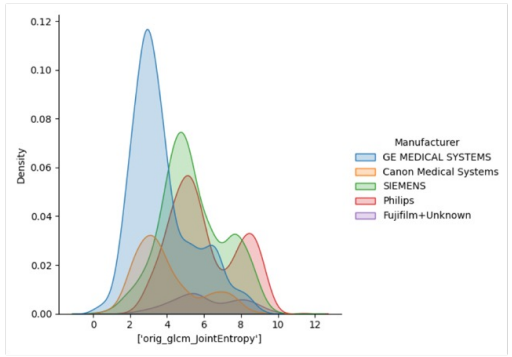
Images source: ADC, Ktrans and PDFF (Quibim SL, Valencia, Spain). SUV (Dimitrakopoulou-Strauss, A. et al. Kinetic modeling and parametric imaging with dynamic PET for oncological applications: general considerations, current clinical applications, and future perspectives. Eur J Nucl Med Mol Imaging (2021)

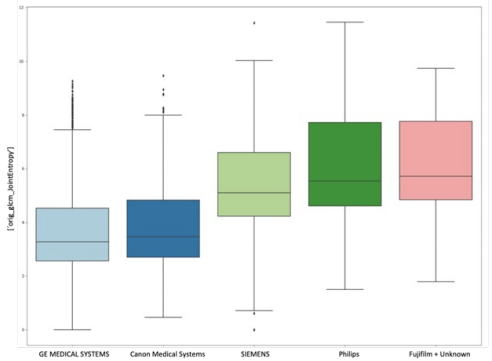
AI models development strategies

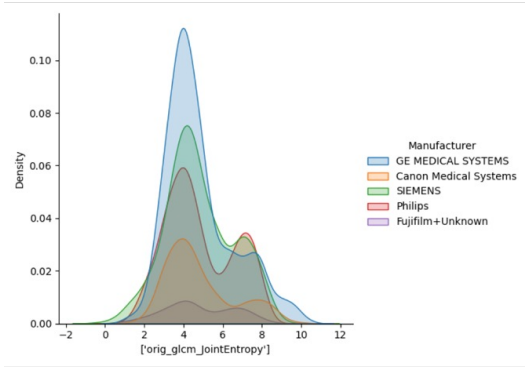
Feature-based models. Features harmonization

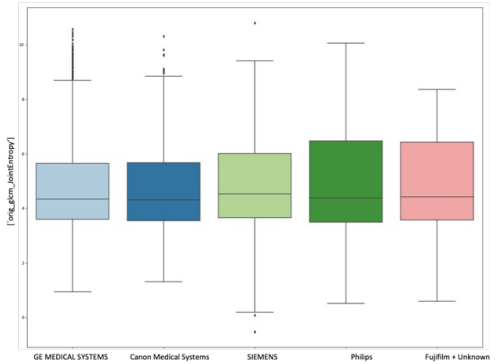
Harmonization techniques to reduce variabilities across manufacturers and sites.

ComBat* is a well-known technique previously used in genomics.



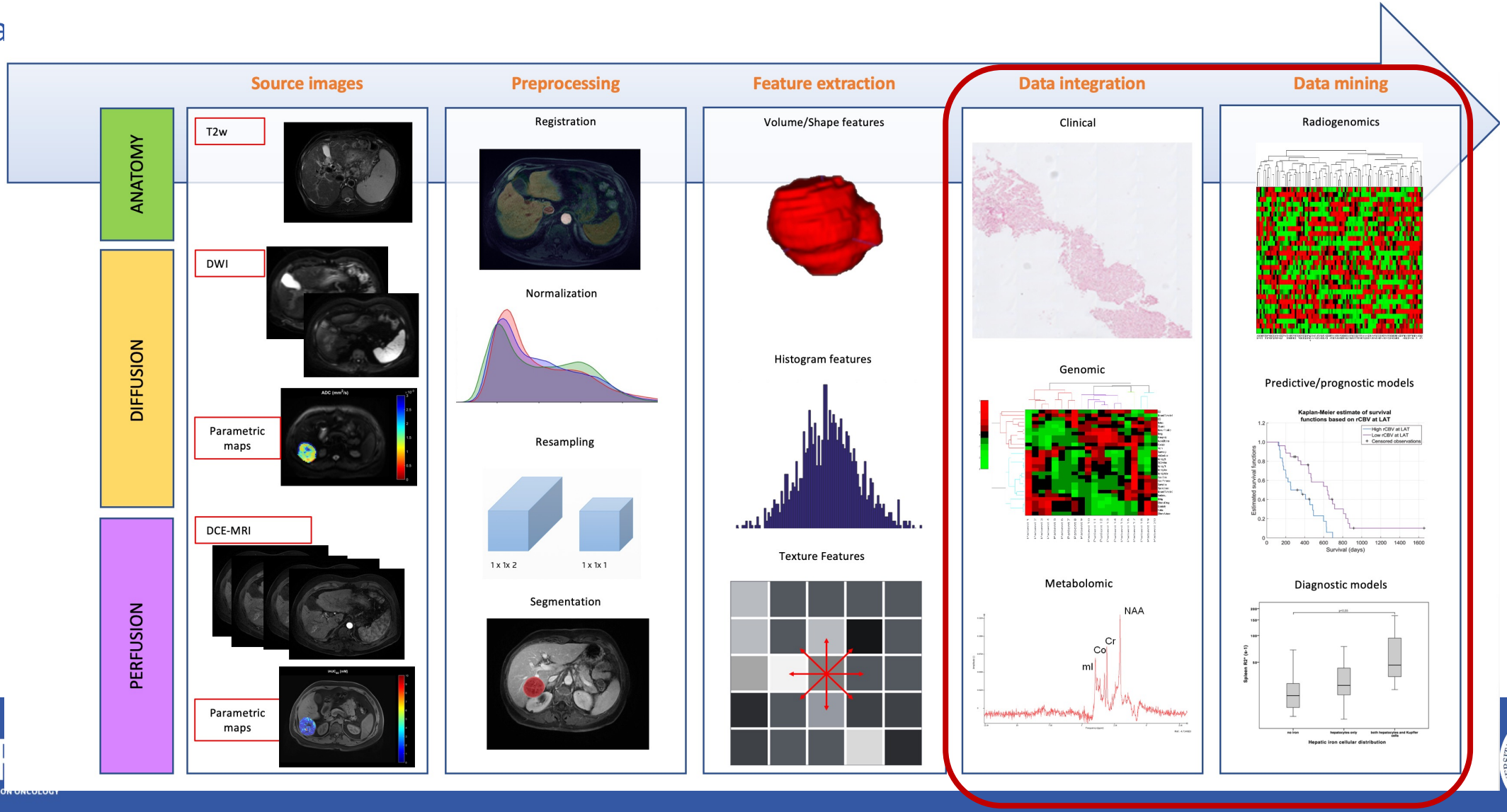






AI models development strategies

Fea



Example

Patient overall survival prediction

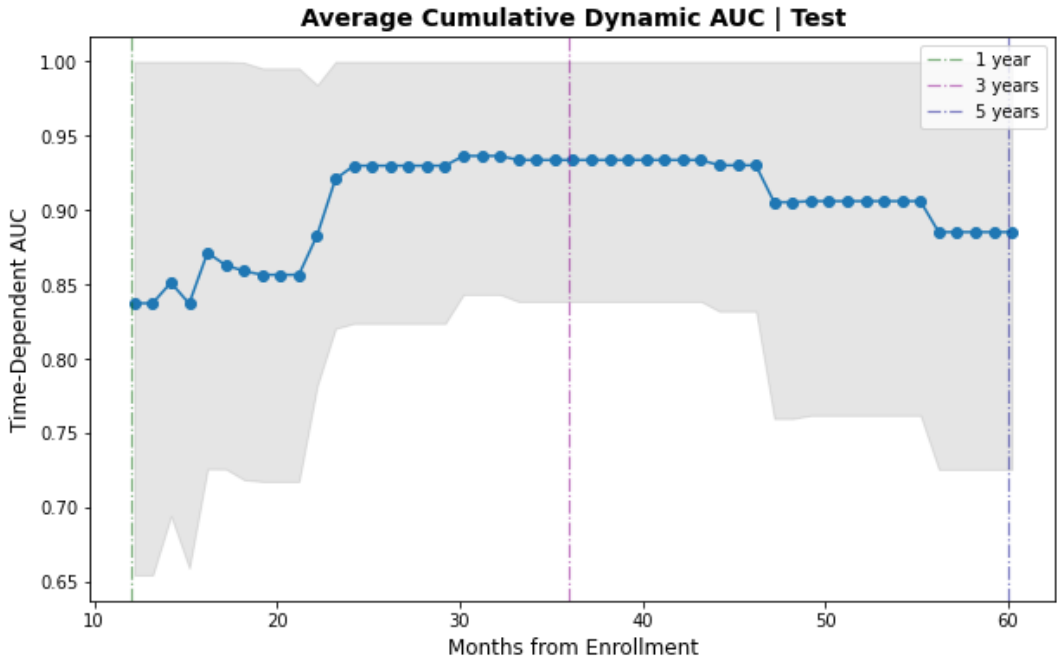
- 118 Neuroblastoma patients
- 156 radiomics features (MRI) + clinical information + molecular data

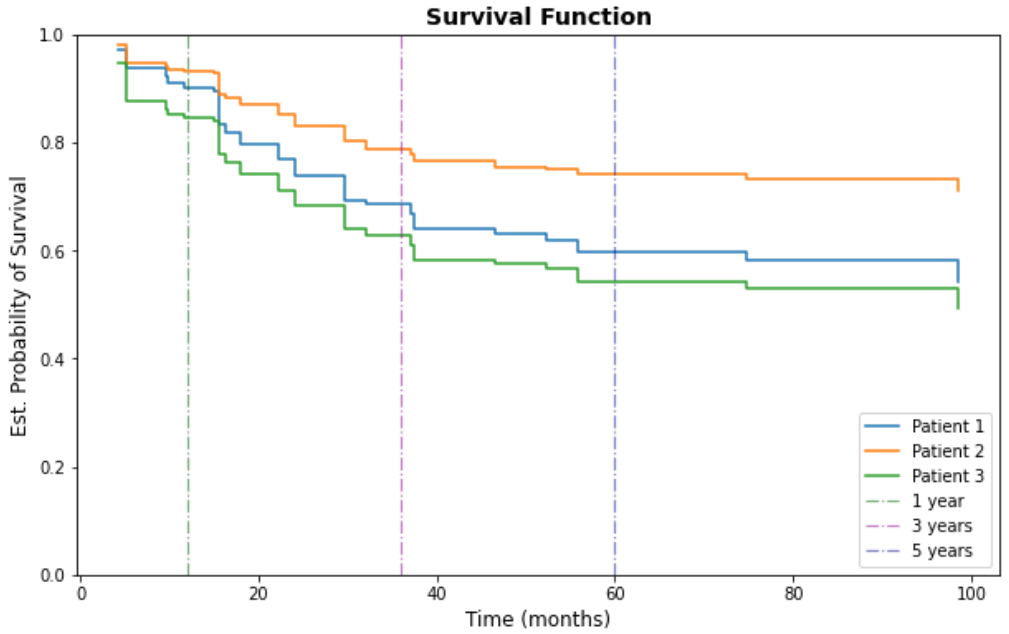
Model	Modifications	C. Index IPCW		C. Index		Mean AUC		Mean Brier Score	
		Train	**Test**	Train	Test	Train	Test	Train	Test
Cox	*Boruta*	0.745	**0.709**	0.785	0.728	0.829	0.875	0.108	0.117
ElasticNet Cox	*Boruta*	0.745	**0.709**	0.785	0.729	0.830	0.875	0.108	0.117
Random Survival Forest	*PCA*	0.913	**0.721**	0.928	0.743	0.962	0.895	0.085	0.123
Extra Survival Trees	*PCA*	0.869	**0.718**	0.893	0.747	0.928	0.827	0.093	0.127
Gradient Boosted Model	*PCA + Remove Outliers*	0.856	**0.712**	0.884	0.736	0.924	0.900	0.107	0.139
Linear SVM	*MRMR*	0.810	**0.731**	0.837	0.721	0.877	0.752	-	-
Gaussian SVM	*MRMR*	0.895	**0.696**	0.909	0.721	0.943	0.762	-	-

Example

Patient overall survival prediction

- 118 Neuroblastoma patients
- 156 radiomics features (MRI) + clinical information + molecular data





Conclusions

- Two main methodologies can be followed to train **AI models** on medical imaging.
- Features-based models are based on the extraction of **radiomics features, deep features or imaging biomarkers**.
- Imaging-based models are based on the use of **Convolutional Neural Networks (CNN)**.
- External validation is crucial to guarantee models **generalization and reproducibility**.
- Radiomics-based models allow the creation of **imaging biomarker panels**.

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