Reliable machine learning algorithms for medical imaging

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ABSTRACT

Recent advances in **machine learning** and **radiomics** challenge **medical imaging** with **requirements for** world-wide **methodological standards**. In clinical practice, **generalization** of deep learning algorithms is **critical** for the secure implementation of computer-aided diagnosis systems. This research aims to provide reliable machine learning in medical imaging to promote the **application of** more adapted and **personalized treatments** to the patient (**P5 medicine**) in **radiomics, genomics and proteomics**.

OBJETIVES

- Increase **generalization** and **interpretability** of **deep learning** algorithms in **medical imaging**.
- Create and curate a **database** of benign and malignant tumors in **lung low-dose CT** scans.
- Preprocess, segment and classify **lung nodules**.
- Perform **radiomic feature extraction** and evaluation.
- Develop **machine learning models** for segmentation, risk stratification, disease progression monitoring, etc.
- Combine the results with **proteomics** and **genomics**.

DEVELOPMENT

2022 — 2023 — 2024 — 2025

Databases
- Clínica Universidad de Navarra: Lung low-dose CT scans, proteomic and genomic data.
- Public databases: NSCLC-Radiomics, LIDC-IDRI dataset, etc.

Deep Learning
- Segmentation.
- Radiomics.
- Integration.
- Generalization.
- Interpretability.

Monitoring
- Clinical tests for implementation in radiology workflow.
- More personalized tratments for patients.

Radiomics
- Preprocessing.
- Harmonization.
- Feature extraction.
- Evaluation and validation.

Guidelines
- Standardization of labeling and image acquisition protocols.

Investigation
- Standardization.
- Generalization in X-ray images.
- Interpretability.
- Radiomics.
- Machine learning.

Combination
- Radiomics.
- Genomics.
- Proteomics.
- Machine learning.

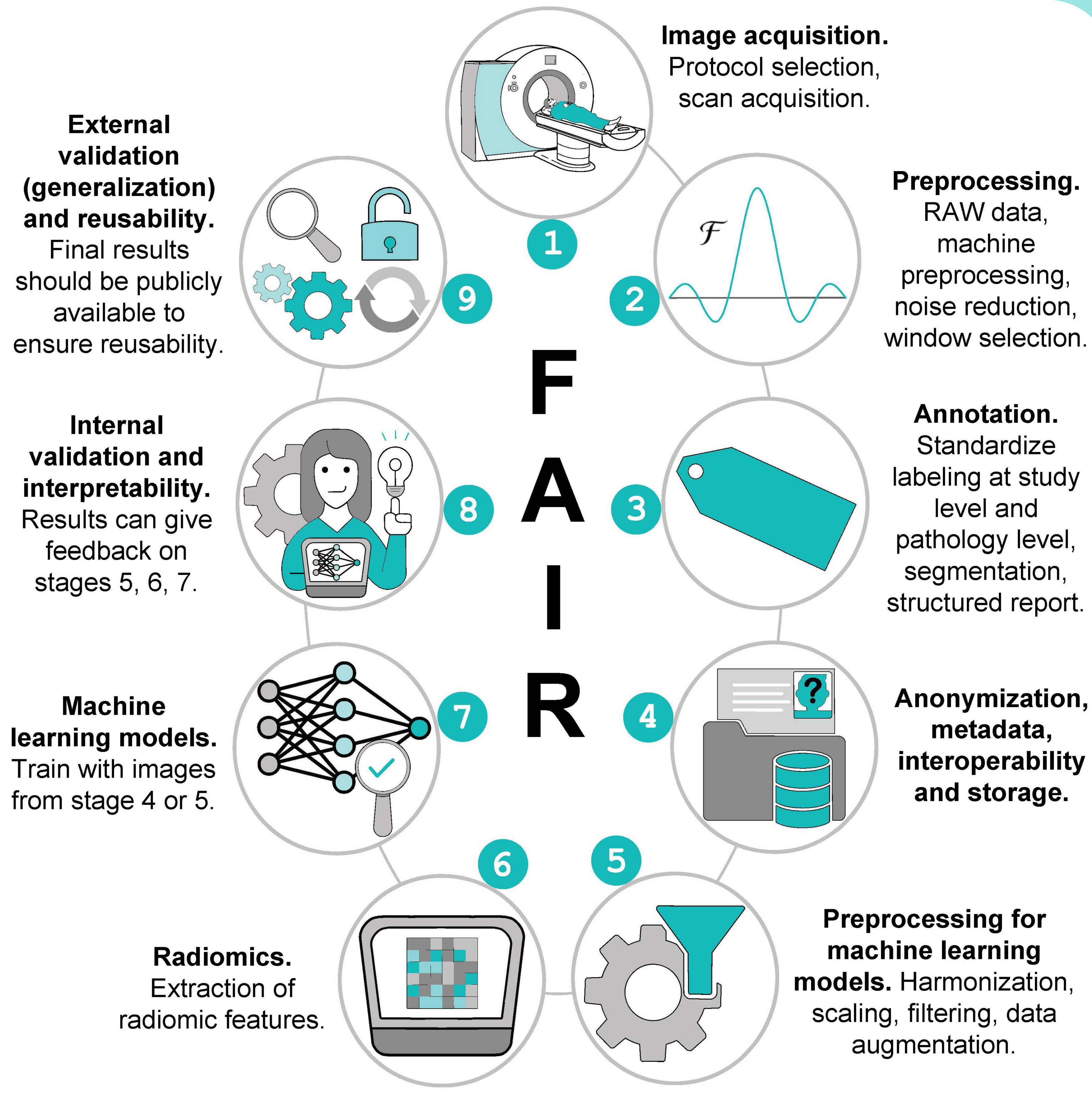

Figure 1. Workflow to develop FAIR principles in medical imaging data.

RESULTS

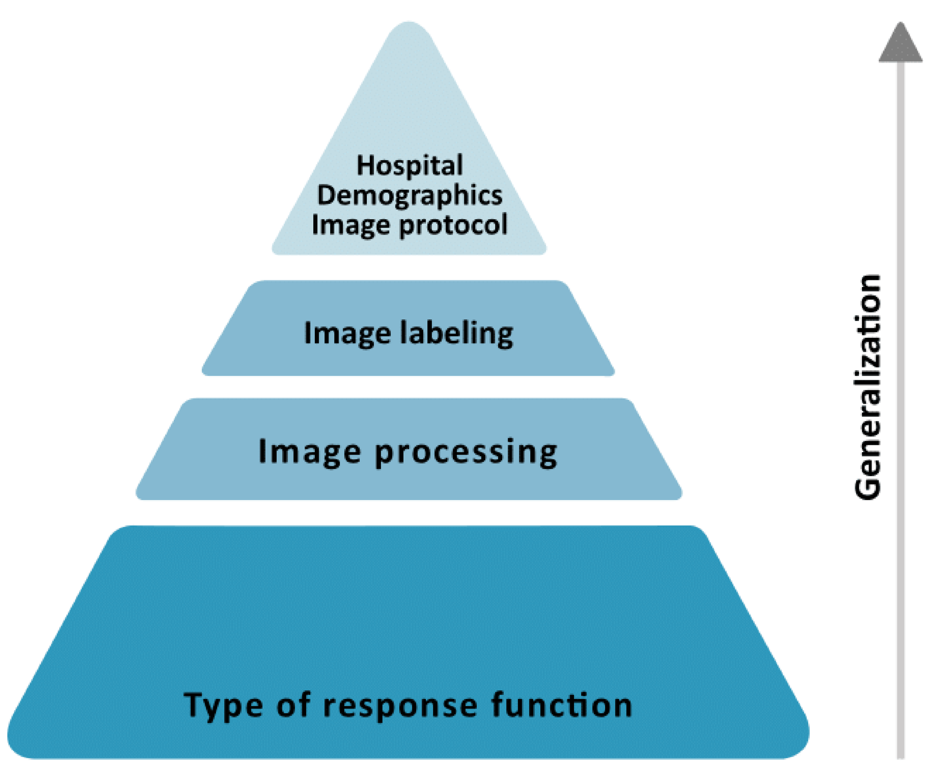

Figure 2. Factors that impact generalization in X-rays.

Generalization in deep learning algorithms for X-ray classification is **hindered** by:
- **Institutional factors** (do not modify pixel values). Performance decreases when the algorithms are adopted in external sites.
- **Device-related factors** (modify pixel values). The type of response function is critical, as it can prevent generalization.

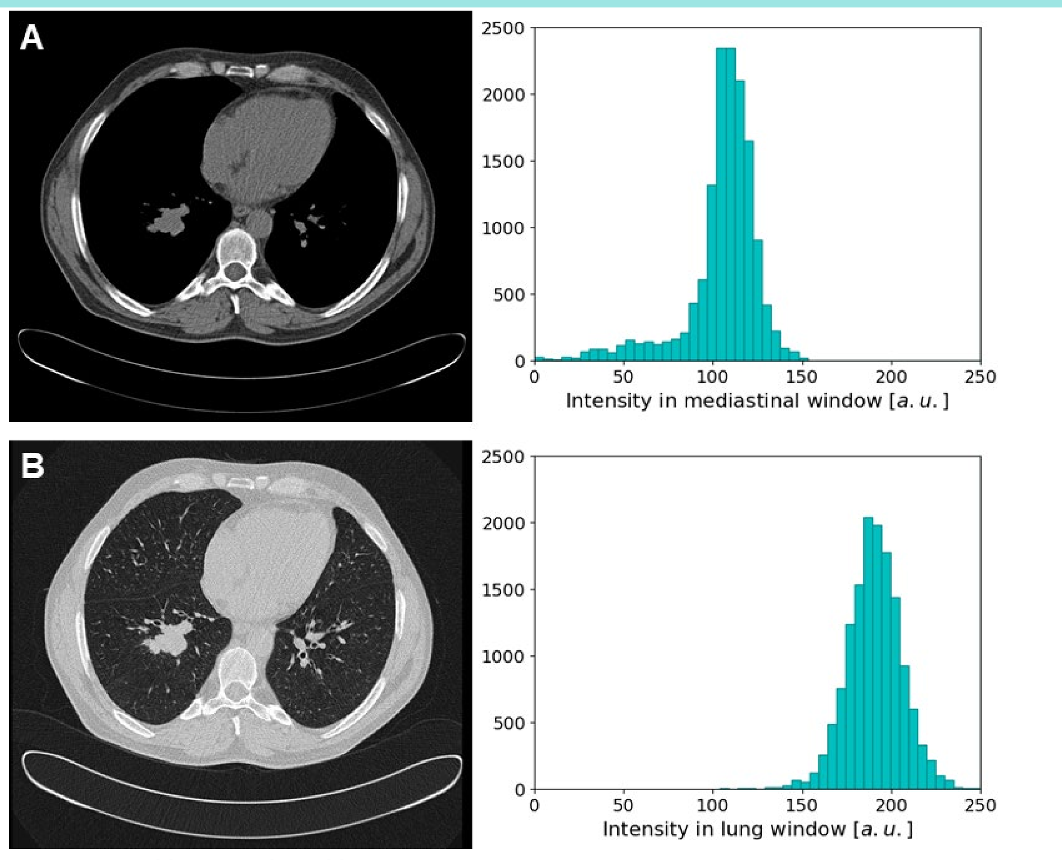

Figure 3. Effect of different image preprocessing on a nodule.

Low-dose CT research:
- Incorporates at least **132 patients** with **201 low-dose CT** scans, including 85 malignant nodules and, minimum, 85 bening nodules.
- Several **image protocolos:** harmonization of reconstruction windows and slice thicknesses.
- Assess cancer types in patients with **radiogenomic** and **radioproteomic** signatures in a more precise and personalized approach (5P medicine).

CONCLUSIONS

- Generalization of deep learning in X-rays is hampered by the type of response function applied by the X-ray device.
- Advances in P5 medicine require a greater understanding of how neural networks learn internally, in addition to which are the factors that impact on generalization.
- Interpretable deep learning algorithms shed light on decision-making understanding, and enhance the confidence of clinicians and patients.
- The **future** of personalization in P5 medicine calls for **collaborative** efforts in highly **interdisciplinary research**.

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