PROJECT 1

DoS: Prof. Maria Picchio

Title: Radiomics and Artificial Intelligence in medical imaging for precision medicine

Curriculum: Experimental and Clinical Medicine

Link to OSR/UniSR personal page:
https://research.hsr.it/en/centers/experimental-imaging-center/maria-picchio.html

https://www.unisr.it/en/docenti/p/picchio-maria

Project description (*Number of characters, including spaces*: 2.000 - 3.000):

Over the past decades, the development of hardware devices and medical imaging technologies has allowed the collection of a huge volume and variety of medical imaging data. Together with advancements in signal processing and machine learning (ML) / deep learning (DL) algorithms, this resulted in an incredible surge of interest in the field of Artificial intelligence (AI)-associated healthcare and Radiomics. Radiomics is an emerging discipline that aims to extract quantitative features ("radiomic features") from medical images. The assumption is that imaging patterns trapped within scans could provide additional, still unexploited sub-visual information, such as descriptors of tumour heterogeneity, pathophysiology and aggressivity. Extracted data is then fed into ML / DL models that will be trained to produce predictions, thus providing knowledge for patient diagnosis, prognosis and personalized treatment planning without the need of invasive tests like biopsy.

AI-based software for low-level technical tasks has already been approved for clinical use, while tools for advanced features (e.g.: AI-based computer aided diagnosis) are currently under investigation and improvement. Due to many reasons all along the pipeline of development, AI-associated healthcare is still in a very early stage, and its adoption has largely been through quite niche use cases. However, it is expected to grow rapidly over the next few years, with commercially adopted algorithms estimated to enter the market very soon. In order to make it happen, research is mandatory and urgently needed to help gaining more prospective evidence and exploring more widespread deployments.

Aim of the project is therefore to consistently provide additional improvements and understanding in this research field, applying handcrafted and DL-based radiomics on medical imaging data, and validating their potential to be applied to address some key clinical questions. This will be done with a focus on both methodological aspects and clinical / precision medicine applications.

Precisely, different types of scanners will be considered, including PET, as well as hybrid PET/CT and PET/MRI. Moreover, several distinct oncological settings will be studied, including neuroendocrine, gynecological (endometrium, ovary, cervix, trophoblast, etc.), prostate, and brain tumours, as well as other neoplastic and non-neoplastic (e.g., vasculitis) pathologies. For each investigation, scans will analyzed, processed and either fed into a properly implemented DL neural network, or segmented for feature extraction, selection and ML model generation. The main goals are: i) development of optimized AI-based approaches for different purposes (diagnostic, prognostic and predictive) and clinical settings (staging, restaging, treatment response, etc.), using well-established gold standards, such as histopathology, immunohistochemistry, genetics, clinical biomarkers, etc.; ii) assessment of the additional value of radiomics and AI technology to clinical models and decision support; iii) evaluation of stability/reproducibility of radiomic features; iv) implementation of different ML/DL algorithms and comparison of their discriminatory ability, for the understanding of their differences, limits and potentialities; v) development of DL-based automated segmentation tools; v) generation of synthetic images to potentially overcome small sample size and class imbalance issues.

Skills to be acquired by the student:

- Ability in understanding, managing, analyzing and integrating several data from different sources of investigation (e.g imaging, clinic, radiomics, genomics, histology)

- Ability in developing and deploying predictive models customized and applied to healthcare use cases using advanced ML / DL algorithms, such as Neural Networks, Decision Trees, Boosting/Ensemble methods, Clustering, etc.

- Knowledge of ML programming languages (Python) and data science libraries and platforms (Pandas, Scikit-learn, Keras, Tensorflow, etc.)

- Knowledge of the pros and cons of different machine learning methods, in order to choose the optimal one for different tasks

- Knowledge of different imaging methodologies (e.g. PET/MRI and PET/CT), including acquisition, data processing, and comprehension of clinical relevance on specific tumour characteristics, in order to optimally extract data that will be used as inputs to predictive models/ statistical analyses ("Feature Design")

- Experience in statistical modelling/data mining and Image data analysis

- Capability in designing and developing the use cases applying a range of different methodologies and technologies

- Being capable to organize several different clinical cases at the same time, developing all the project phases, tackling research problems, proposing and applying possible solutions

- Ability to effectively interpret the research results with critical judgement, being able to translate results obtained by computational analyses into clinical needs.

- Ability to work in multidisciplinary environments, providing substantial contribution to the team cooperation

References (max. 3)

Bi WL, Hosny A, Schabath MB, Giger ML, Birkbak NJ, Mehrtash A, Allison T, Arnaout O, Abbosh C, Dunn IF, Mak RH, Tamimi RM, Tempany CM, Swanton C, Hoffmann U, Schwartz LH, Gillies RJ, Huang RY, Aerts HJWL. Artificial intelligence in cancer imaging: Clinical challenges and applications. CA Cancer J Clin. 2019 Mar;69(2):127-157. doi: 10.3322/caac.21552. Epub 2019 Feb 5. PMID: 30720861; PMCID: PMC6403009.

Miller DD, Brown EW. Artificial Intelligence in Medical Practice: The Question to the Answer? Am J Med. 2018 Feb;131(2):129-133. doi: 10.1016/j.amjmed.2017.10.035. Epub 2017 Nov 7. PMID: 29126825.