

Pragmatic outcomes from medical imaging

Dr. Alberto Traverso

Department of Radiotherapy, Maastro Clinic, Maastricht, The Netherlands

alberto.traverso@maastro.nl



SCAN ME



“And now here is my secret, a very simple secret:
It is only with the ~~heart~~ that one can see rightly;
what is essential is invisible to the eye.”

-The Little Prince by
Antoine de Saint-Exupéry

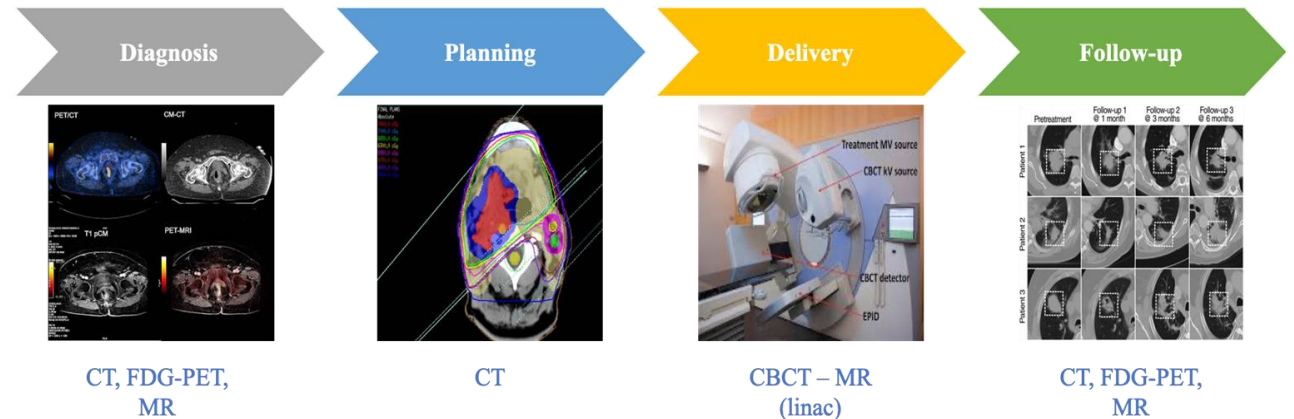
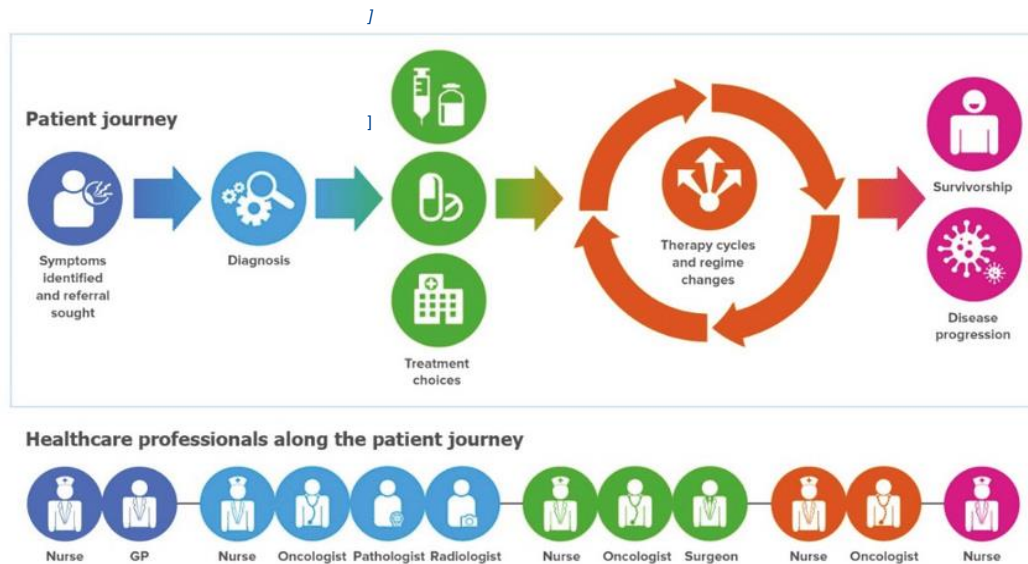
AI+ medical
imaging

WHY

The medical imaging continuum

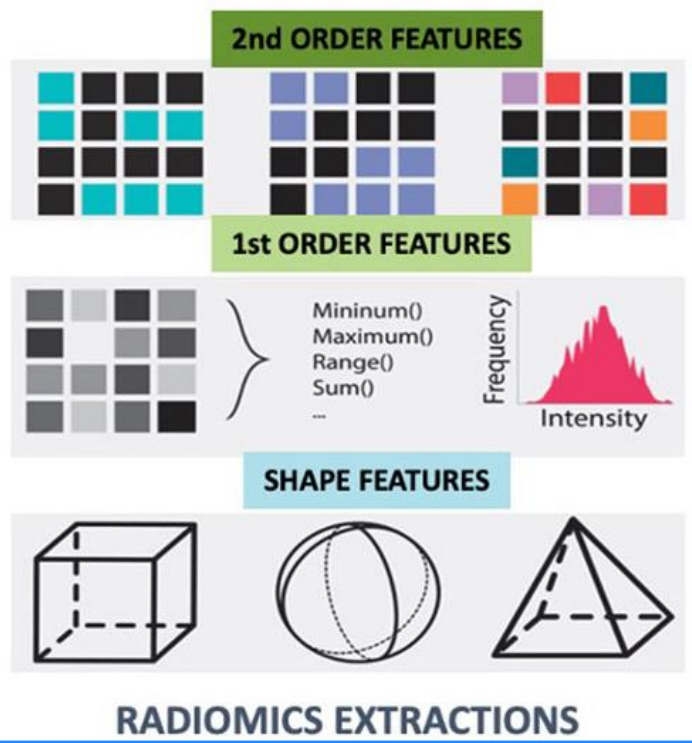
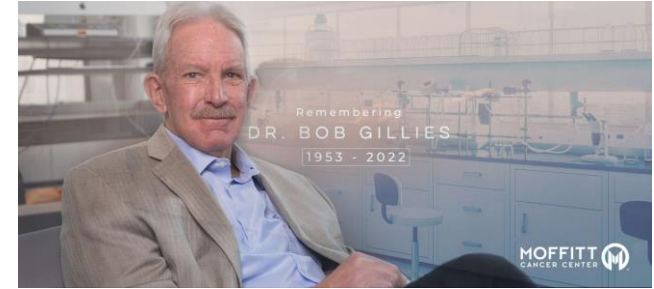
“Medical imaging plays a key role in (radiation) oncology [...]; but we are still facing a **sub-optimal** use of medical imaging”

[Welch, Traverso, Jaffray, Chung, “The modern technology of radiation oncology”, ISBN 978-1-951134-03-7 (2020)]



HOW

Images as (unstructured) DATA



JOURNAL ARTICLE

Editorial: Radiomics: The New World or Another Road to El Dorado? FREE

Mattea L. Welch, David A. Jaffray ✉

“We would argue that the major contribution of radiomics is not in the identification of a set of image-based biomarkers, but rather in its illumination of a critical “tipping point” in technological capability that will both challenge and enable the clinical and research oncology community”

Radiology

Radiomics: Images Are More than Pictures, They Are Data¹

Robert J. Gillies, PhD
Paul E. Kinahan, PhD
Hedvig Hricak, MD, PhD, Dr(PhC)

In the past decade, the field of medical image analysis has grown exponentially, with an increased number of pattern recognition tools and an increase in data set sizes. These advances have facilitated the development of processes for high-throughput extraction of quantitative features that result in the conversion of images into mineable data and the subsequent analysis of these data for decision support; this practice is termed *radiomics*. This is in contrast to the traditional practice of treating medical images as pictures intended solely for visual interpretation. Radiomic data contain first-, second-, and higher-order statistics. These data are combined with other patient data and are mined with sophisticated bioinformatics tools to develop models that may potentially improve diagnostic, prognostic, and predictive accuracy. Because radiomics analyses are intended to be conducted with standard of care images, it is conceivable that conversion of digital images to mineable data will eventually become routine practice. This report describes the process of radiomics, its challenges, and its potential power to facilitate better clinical decision making, particularly in the care of patients with cancer.

AI to give structure



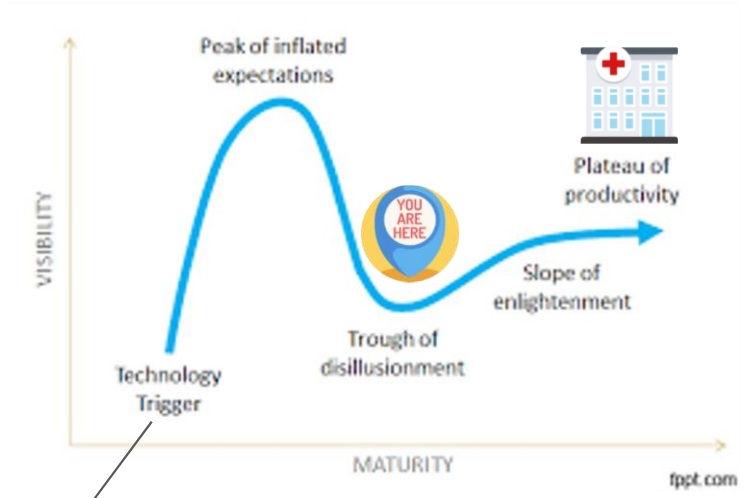
What is AI for Maastrro?

“Algorithms primarily learned from data (so not pre-specified / based on a physical, biological or another mechanistic model)”

Maastrro

Radiomics “renewal”

Great times ahead of us !

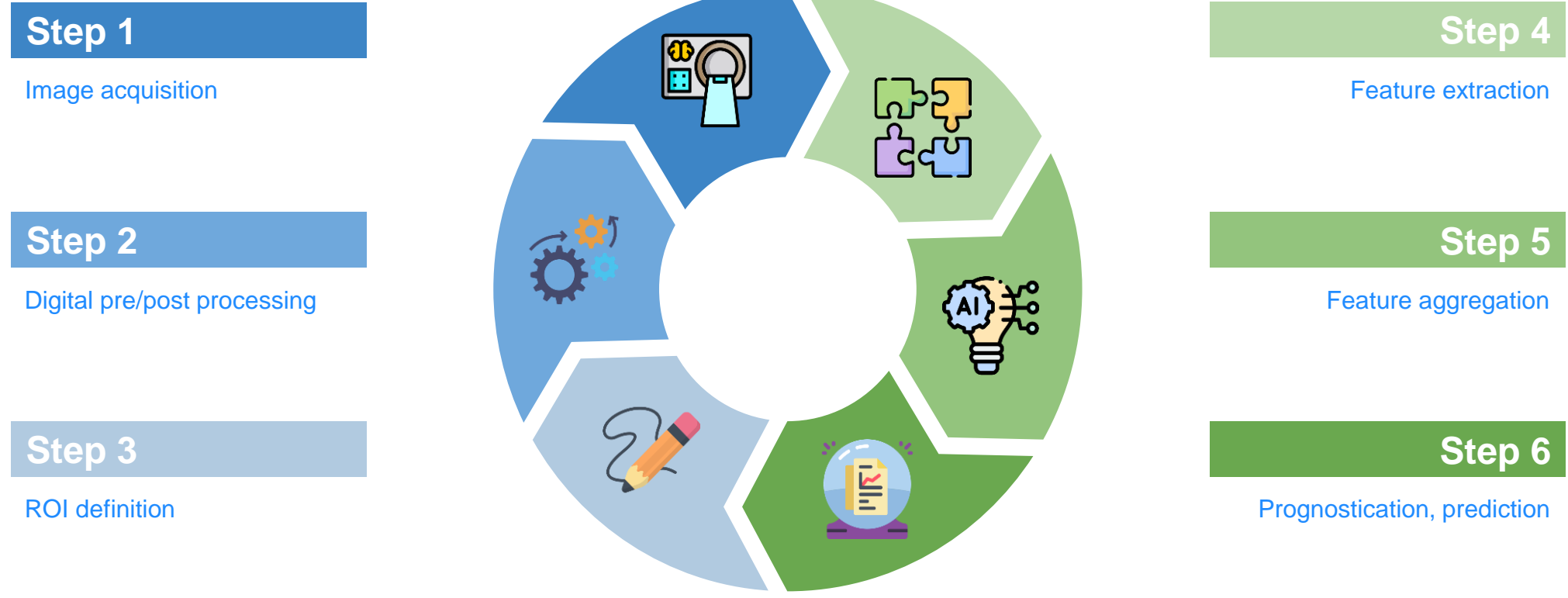


2014

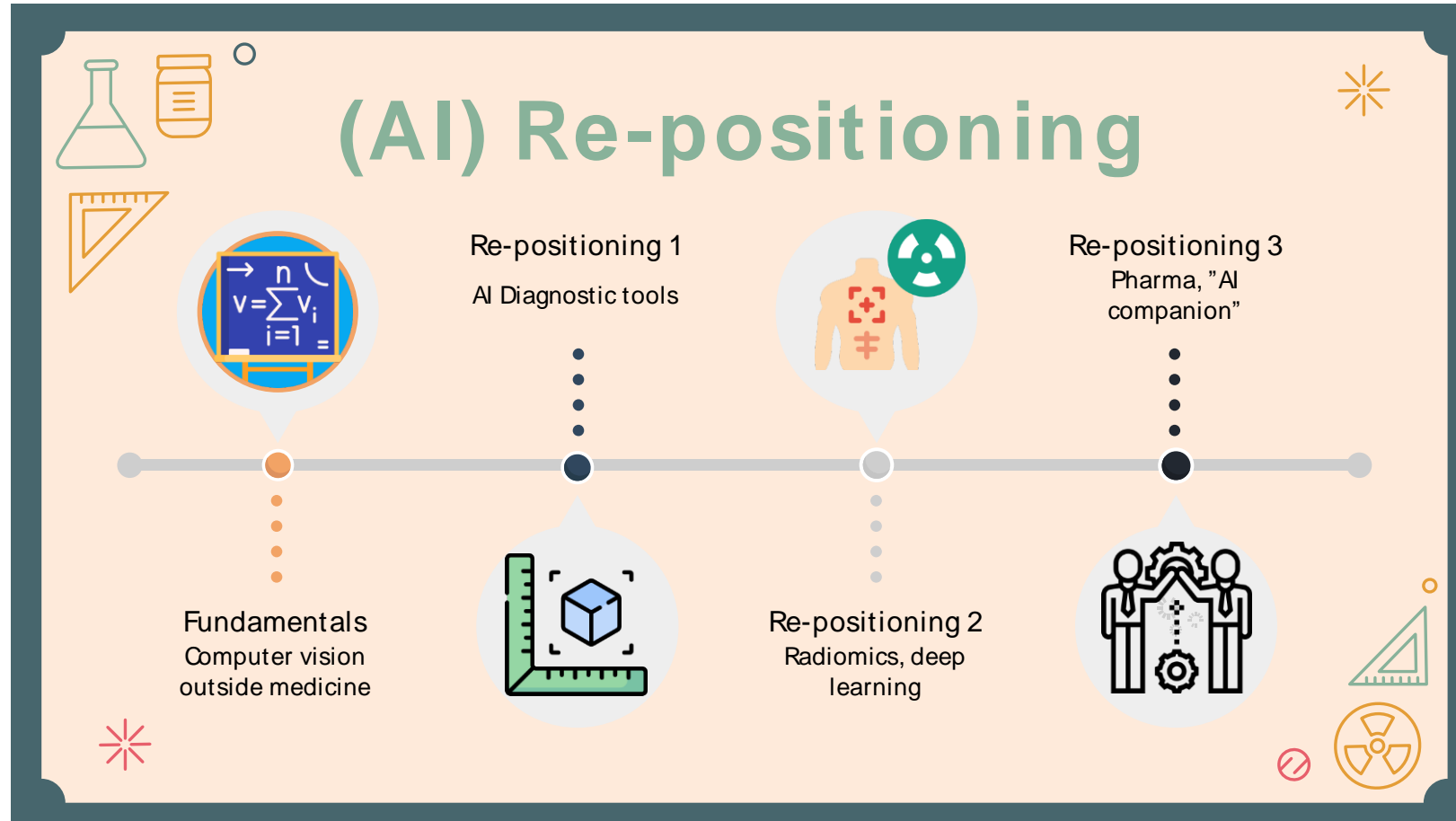


Radiomics
Renewal

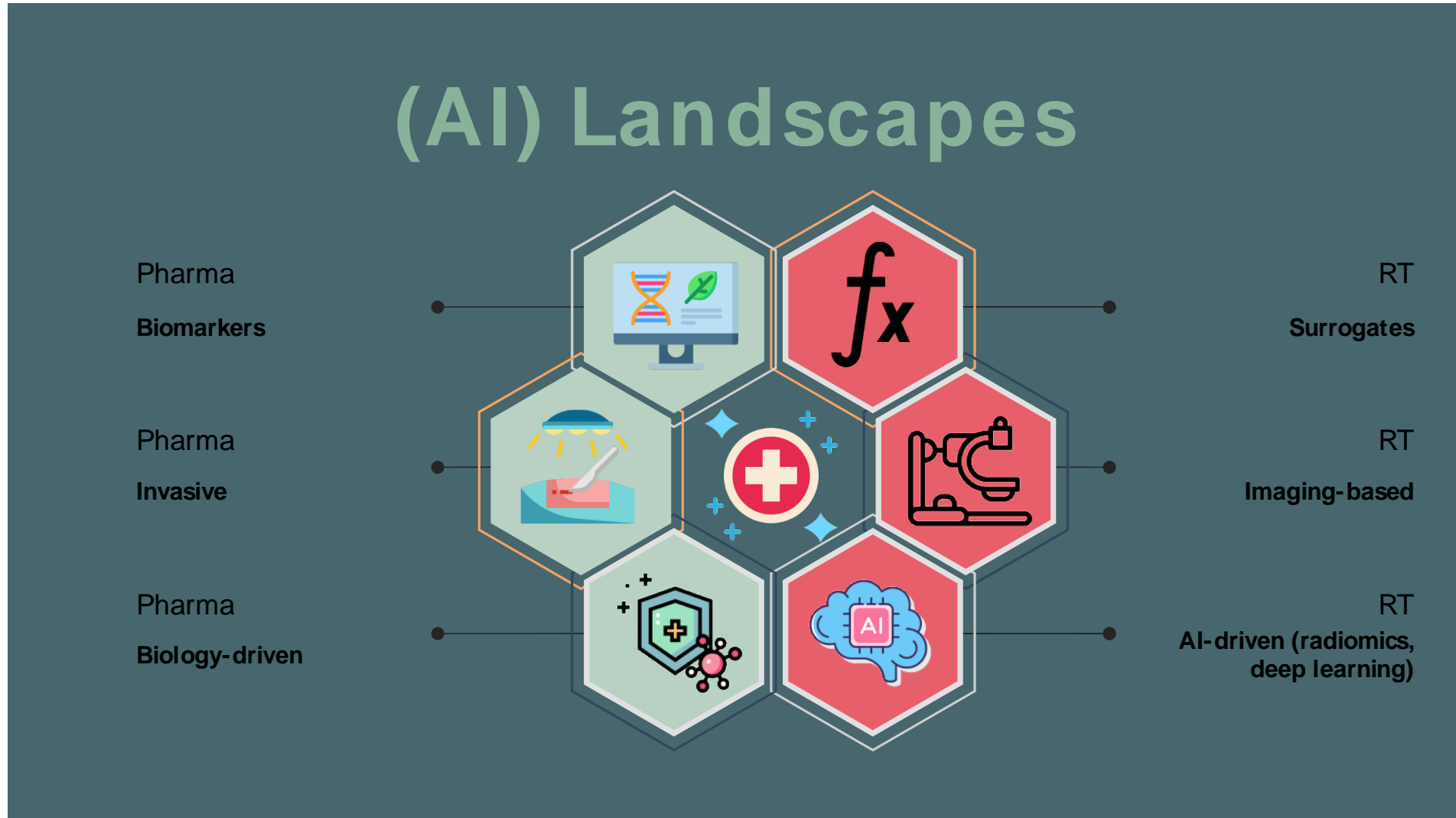
Radiomics does not live in a VACUUM! (a.k.a. OSIRIS for radiomic lovers!)



AI re-positioning (a.k.a. ETL for radiomic lovers!)



AI landscapes (a.k.a. maturity survey for radiomic lovers!)

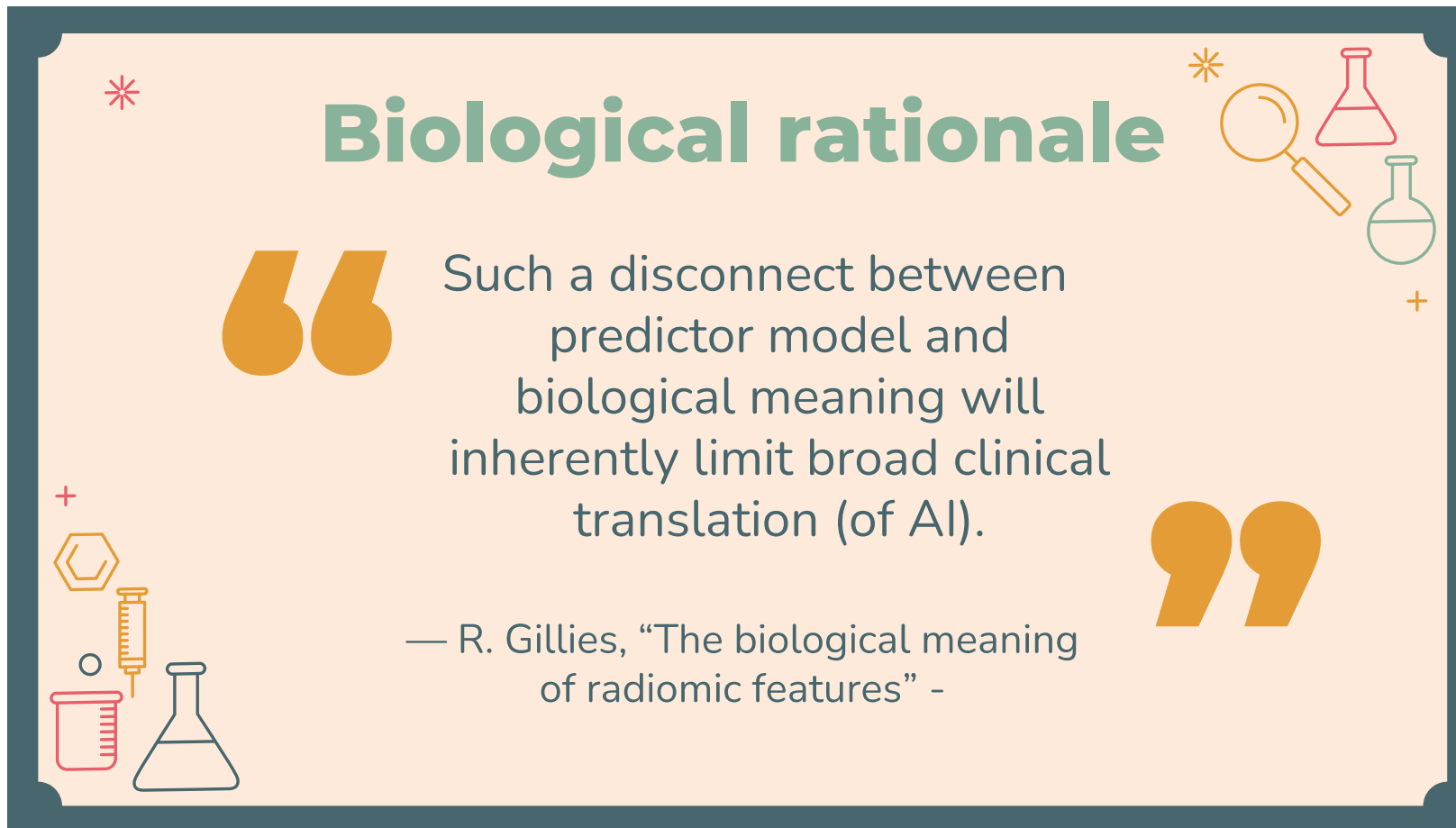


Biological rationale (a.k.a. very hard variables for radiomic lovers!)

Biological rationale

“ Such a disconnect between predictor model and biological meaning will inherently limit broad clinical translation (of AI). ”

— R. Gillies, “The biological meaning of radiomic features” -



WHAT

Informed decisions



Response

Tumor



Side-effects

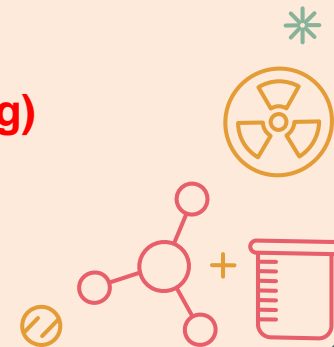
Host

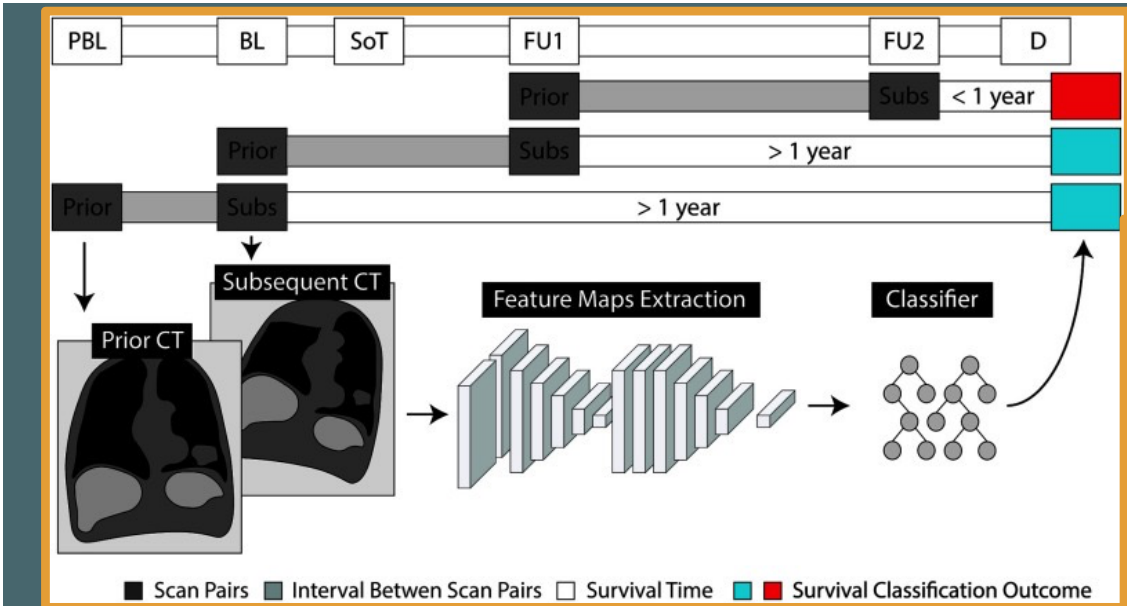


(Immune) Profiling

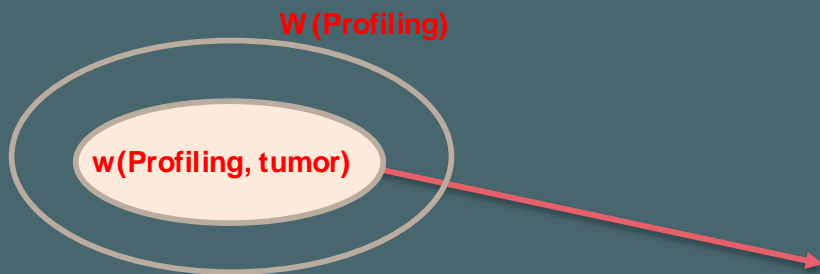
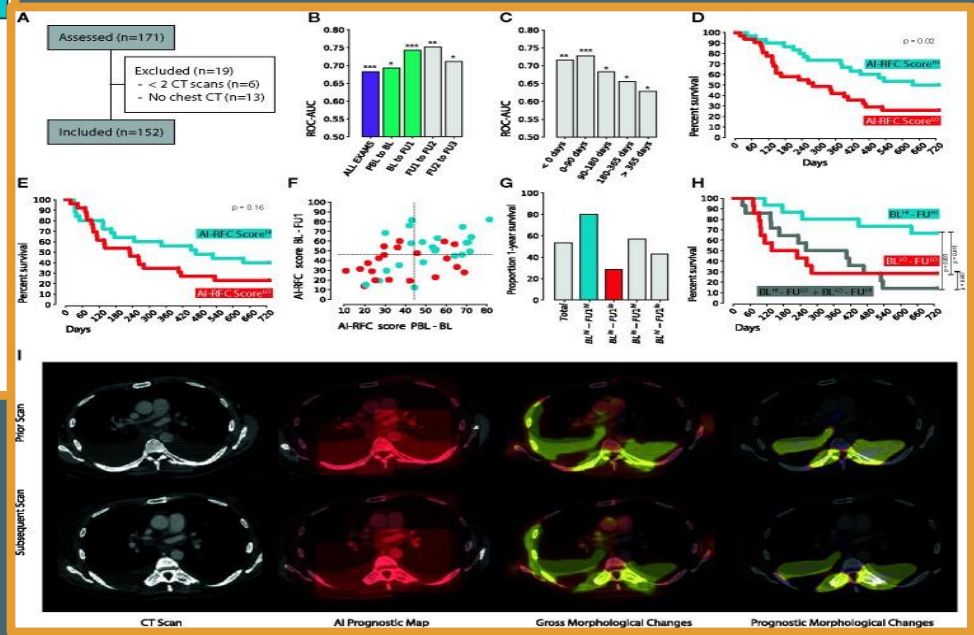
Tumor,
Host

$$P(\text{success}) = [P(\text{response}) - P(\text{side-effects})] \times W(\text{Profiling})$$

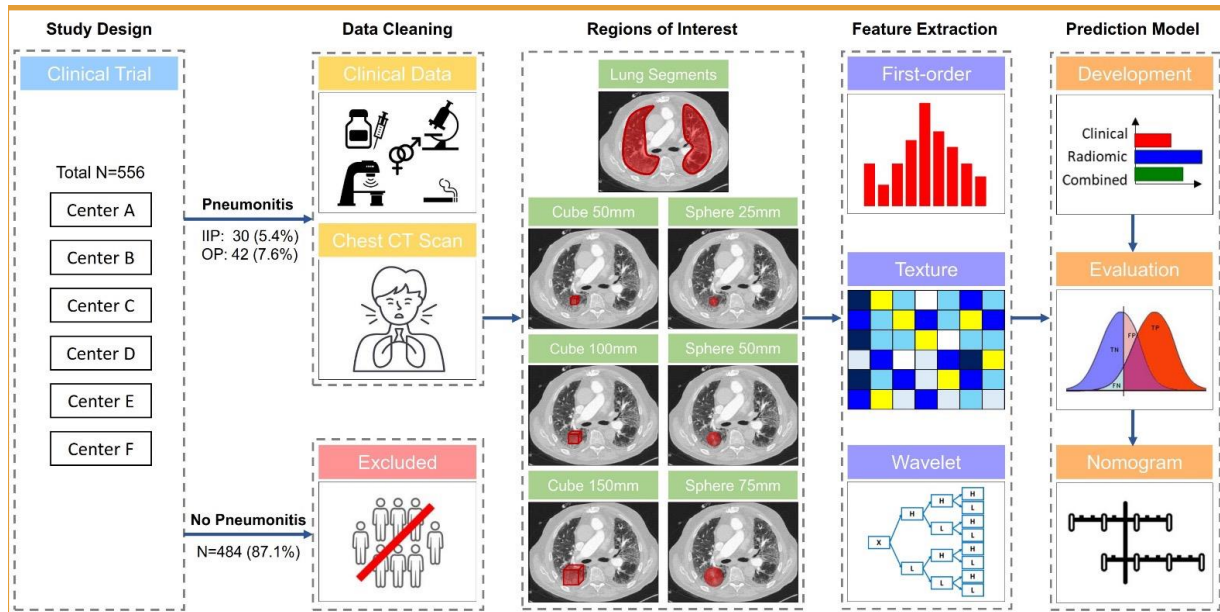




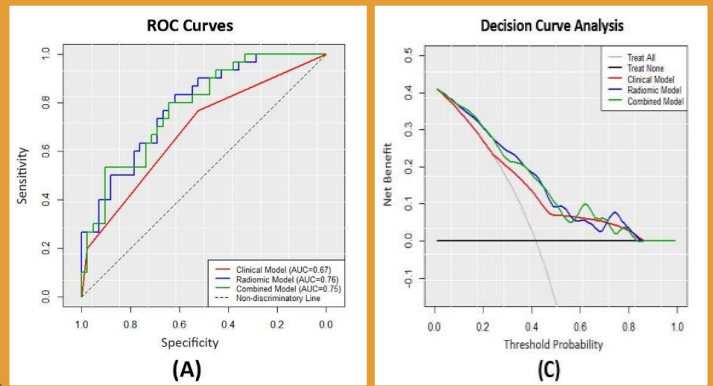
Trebeschi, Aerts et al, "Prognostic Value of Deep Learning-Mediated Treatment Monitoring in Lung Cancer Patients Receiving Immunotherapy" (frontiers Oncol. 2021 Mar 2;11:609054)



Results showed our RFC survival score preserved statistical significance against age, volumetric change of total tumor burden, >1% PDL-1 expression [..]

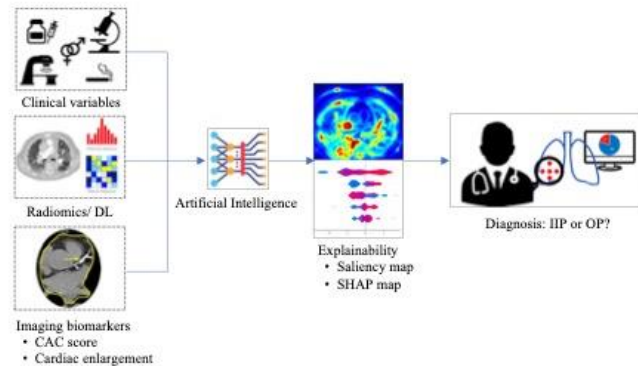


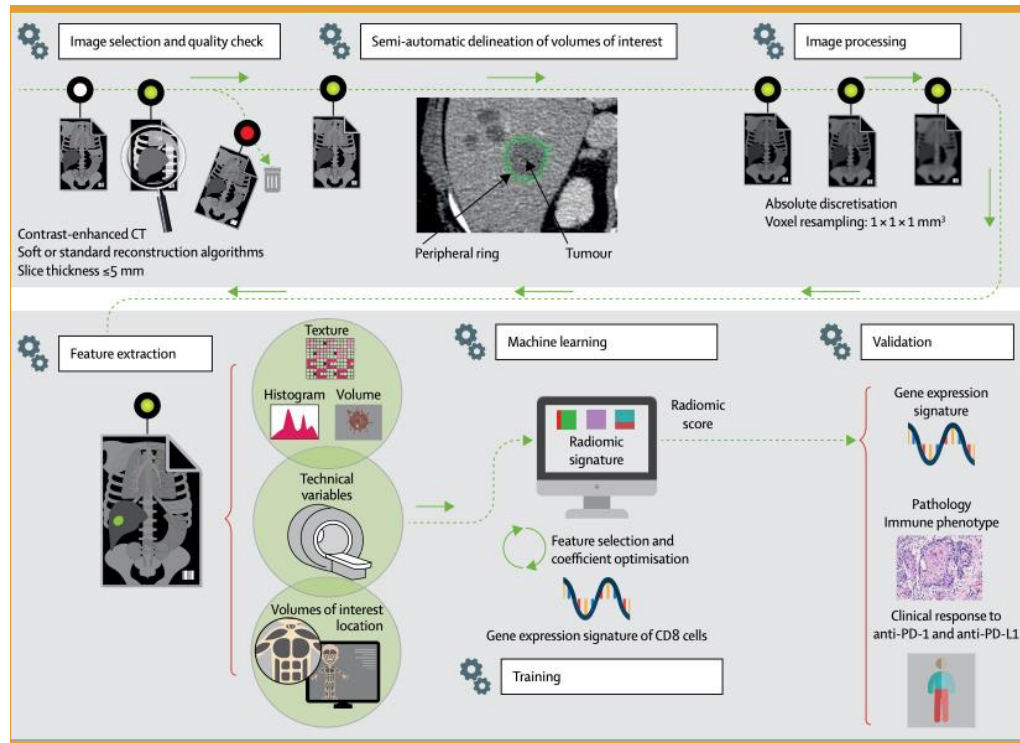
Tohidinezhad, Bontempi, Dekker, Aerts, De Ruyscher, Traverso et al, "CT-based Radiomics for the Differential Diagnosis of Pneumonitis in Stage IV Non-Small Cell Lung Cancer Patients Treated with Immune Checkpoint Inhibitors" (submitted to JAMA)



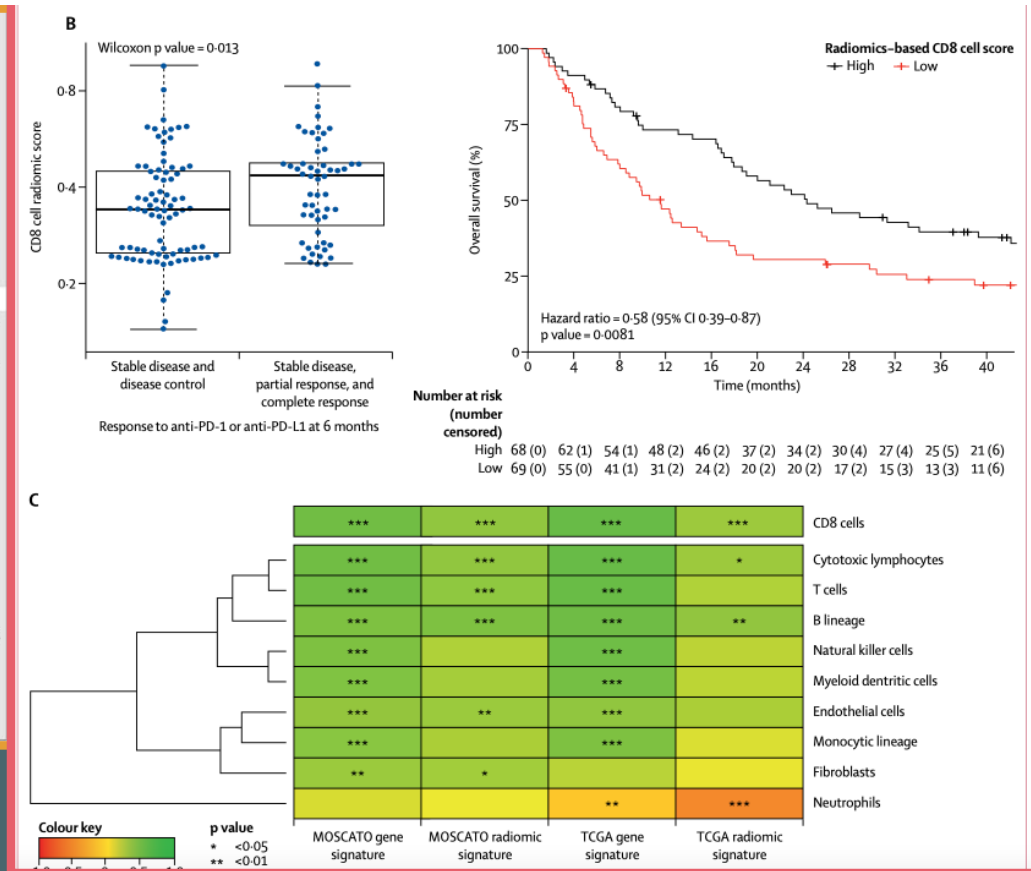
W(Profiling, host)

DSS: Predicting the differential diagnosis of pneumonitis using data at the time of dyspnea manifestation

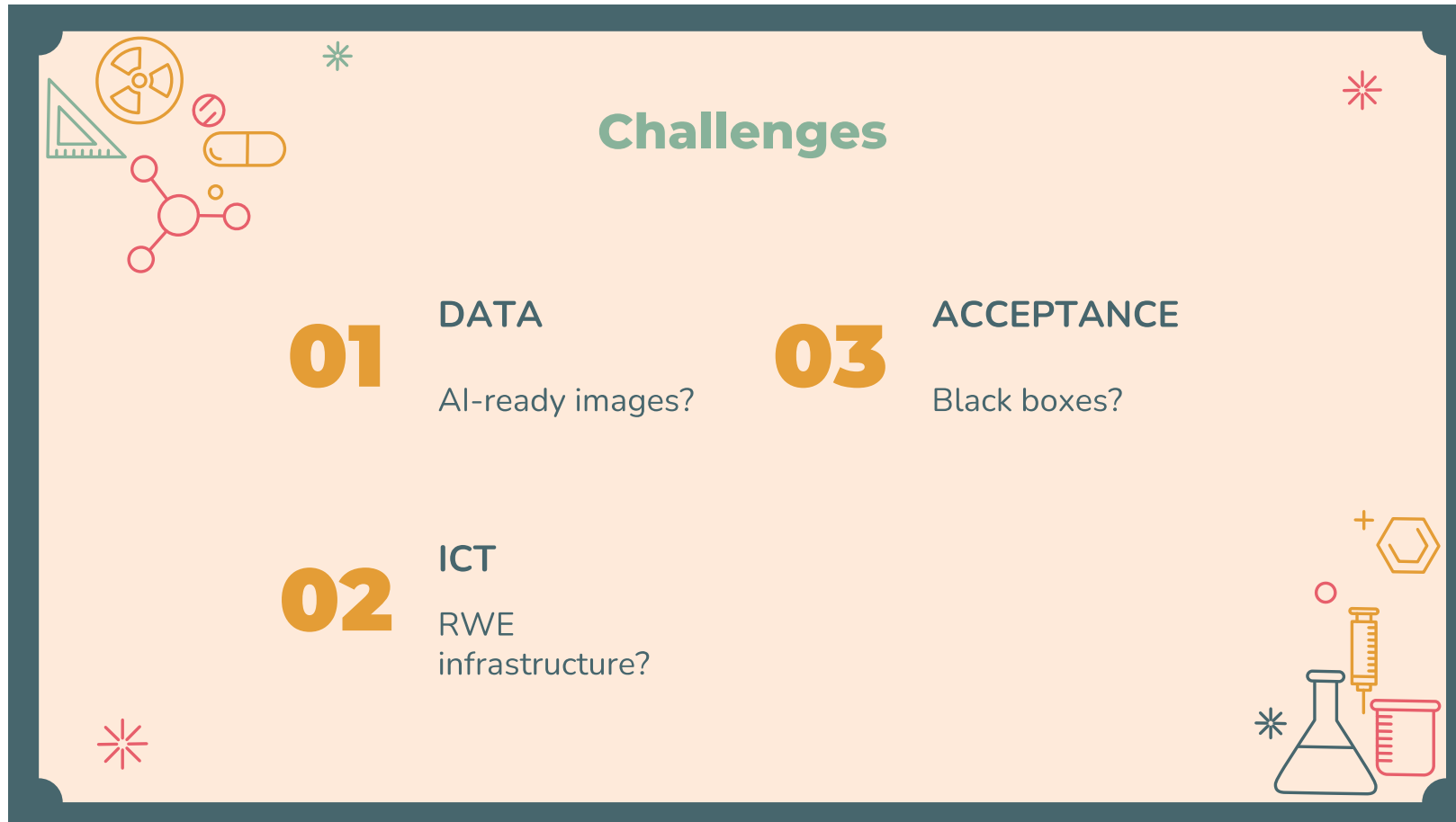




Future prospective studies could incorporate these three phenotypes or, perhaps, **additional immunological** subtypes as understanding of the tumour and stromal immune functions develops.





Sun, Deutsch et al “A radiomics approach to assess tumour-infiltrating CD8 cells and response to anti-PD-1 or anti-PD-L1 immunotherapy: an imaging biomarker, retrospective multicohort study” (The Lancet Oncology).



STANDARDIZATION


Original Research Article

Learning from scanners: Bias reduction and feature correction in radiomics

Ivan Zhovannik ^{a, b}  , Johan Bussink ^a, Alberto Traverso ^{b, c}, Zhenwei Shi ^b, Petros Kalendralis ^b, Leonard Wee ^b, Andre Dekker ^b, Rianne Fijten ^b, René Monshouwer ^a

PAPER • OPEN ACCESS

Generative models improve radiomics reproducibility in low dose CTs: a simulation study


Junhua Chen ¹ , Chong Zhang ¹, Alberto Traverso ¹, Ivan Zhovannik ^{1,2}, Andre Dekker ¹, Leonard Wee ^{3,1} and Inigo Bermejo ^{3,1}

Published 3 August 2021 • © 2021 The Author(s). Published on behalf of Institute of Physics and Engineering in Medicine by IOP Publishing Ltd

[Physics in Medicine & Biology](#), Volume 66, Number 16

Open Access Article

Segmentation Uncertainty Estimation as a Sanity Check for Image Biomarker Studies

by  Ivan Zhovannik ^{1,2,3,*} ,  Dennis Bontempi ² ,  Alessio Romita ² ,  Elisabeth Pfaehler ^{2,4} ,  Sergey Primakov ⁵ ,  Andre Dekker ² ,  Johan Bussink ¹ ,  Alberto Traverso ^{2,†}  and  René Monshouwer ^{1,†} 

> [Phys Med.](#) 2020 Mar;71:24–30. doi: 10.1016/j.ejmp.2020.02.010. Epub 2020 Feb 20.

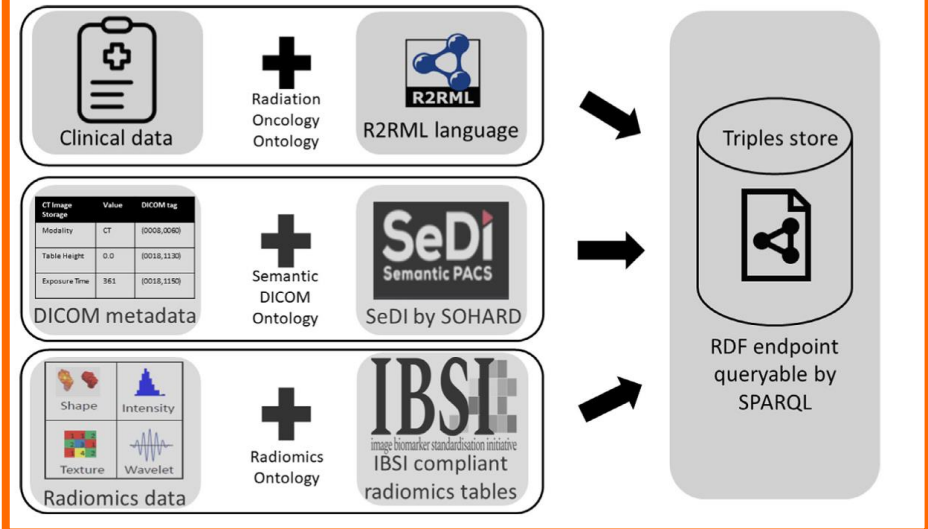
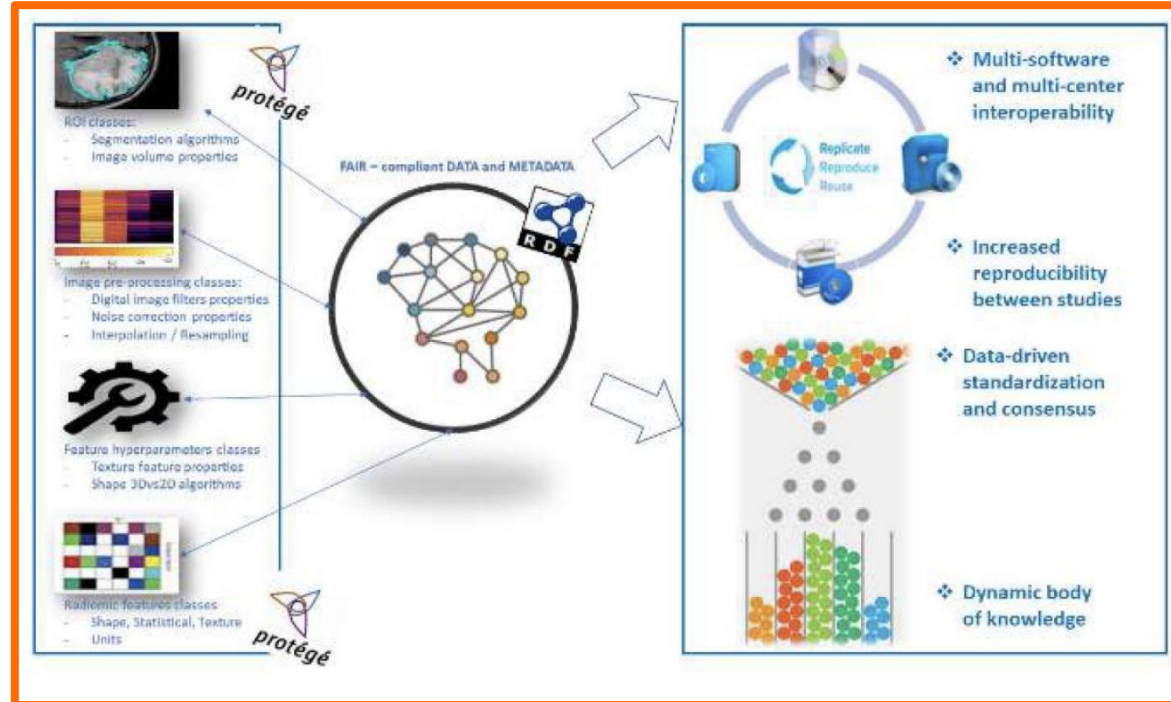
Machine learning helps identifying volume-confounding effects in radiomics

Alberto Traverso ¹, Michal Kazmierski ², Ivan Zhovannik ³, Mattea Welch ⁴, Leonard Wee ², David Jaffray ⁵, Andre Dekker ², Andrew Hope ⁵

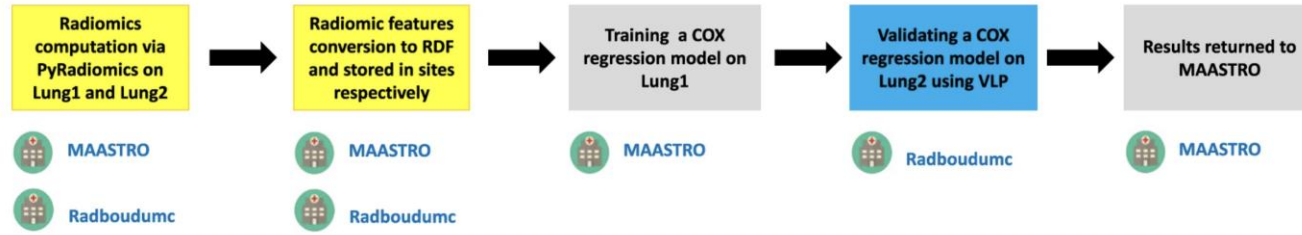
Affiliations + expand

PMID: 32088562 DOI: 10.1016/j.ejmp.2020.02.010

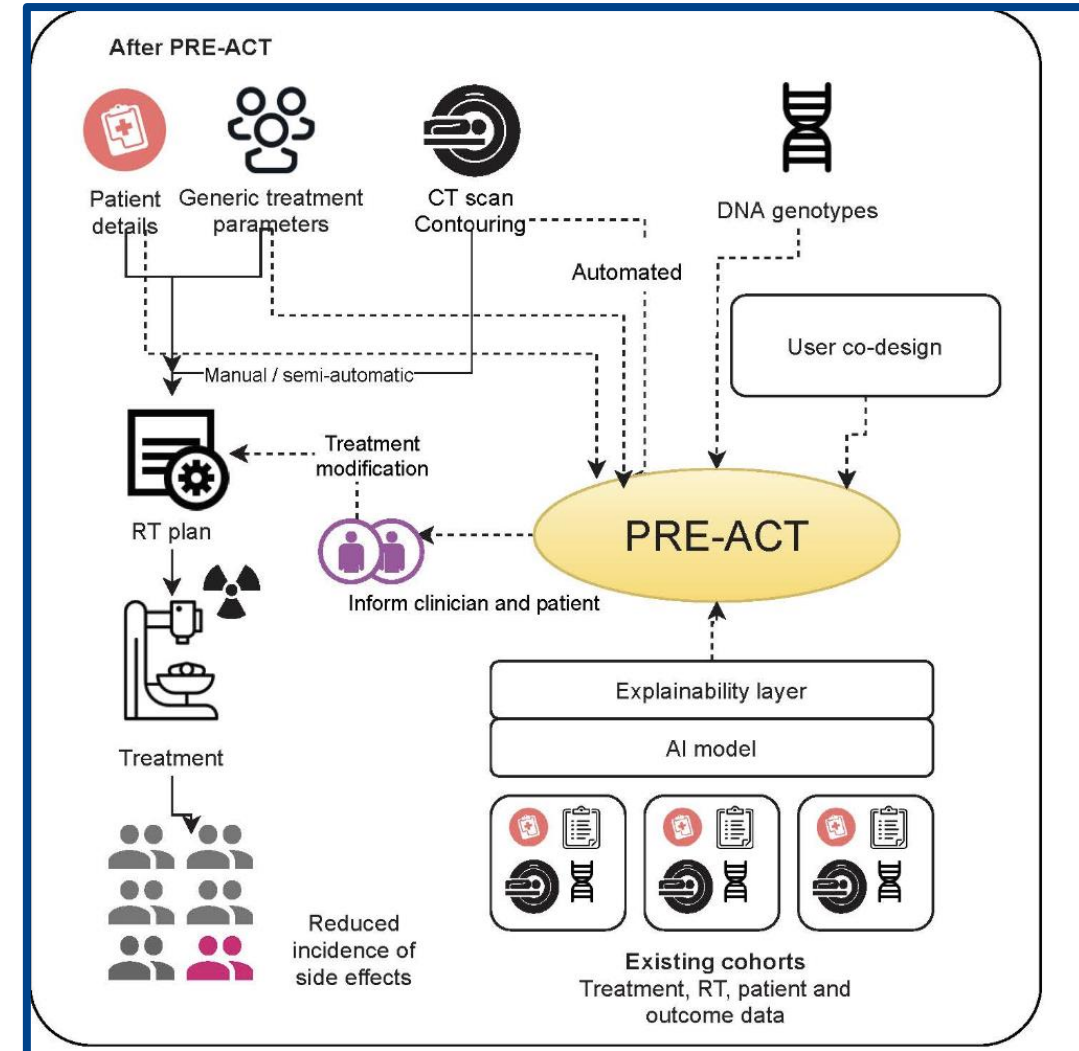
Free article



From: [Distributed radiomics as a signature validation study using the Personal Health Train infrastructure](#)

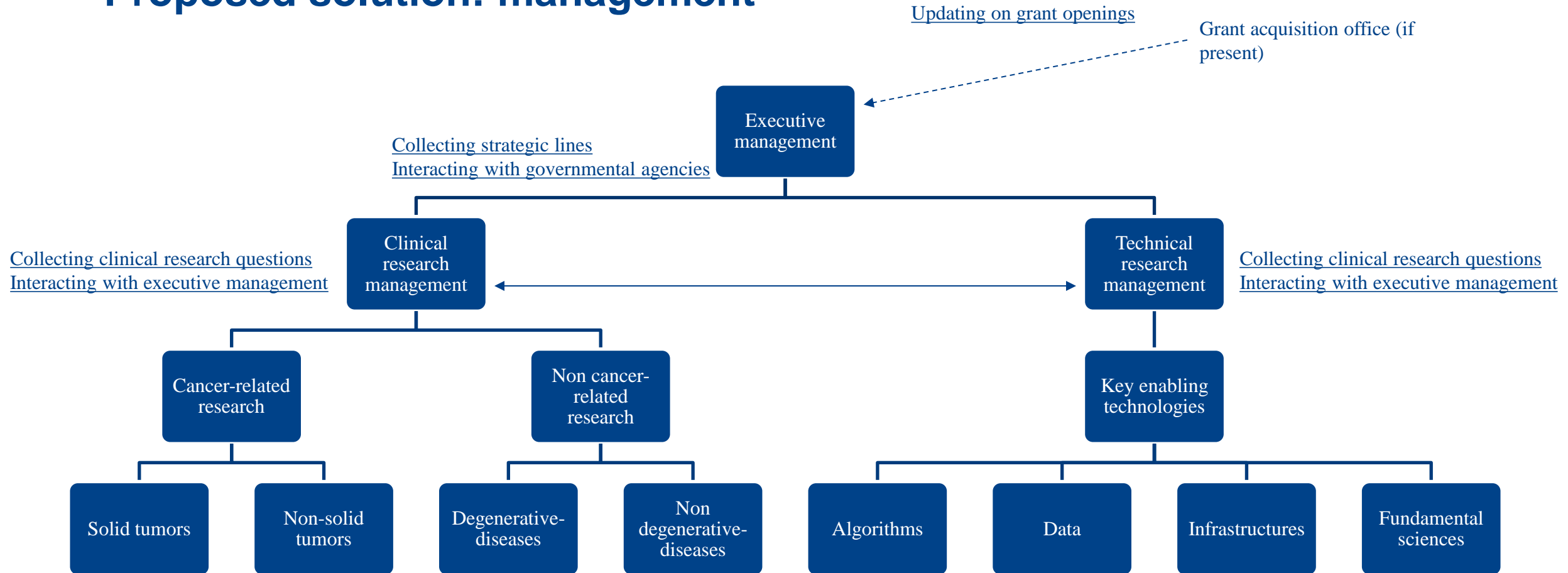


individual subject level. This is an essential and unique contribution to radiomic investigations, because we hereby demonstrate the concept for carrying out multi-centre radiomic studies with fully decentralized data. The results obtained with decentralized data were the same as if all the data had been brought into the same location. However, the unique advantage of our approach is that no one party needs to risk breaking patient confidentiality by exposing the original data to another party. Each institutional data owner retains complete control over their privacy-sensitive patient data, and decides what they wish to share for a collaborative project.



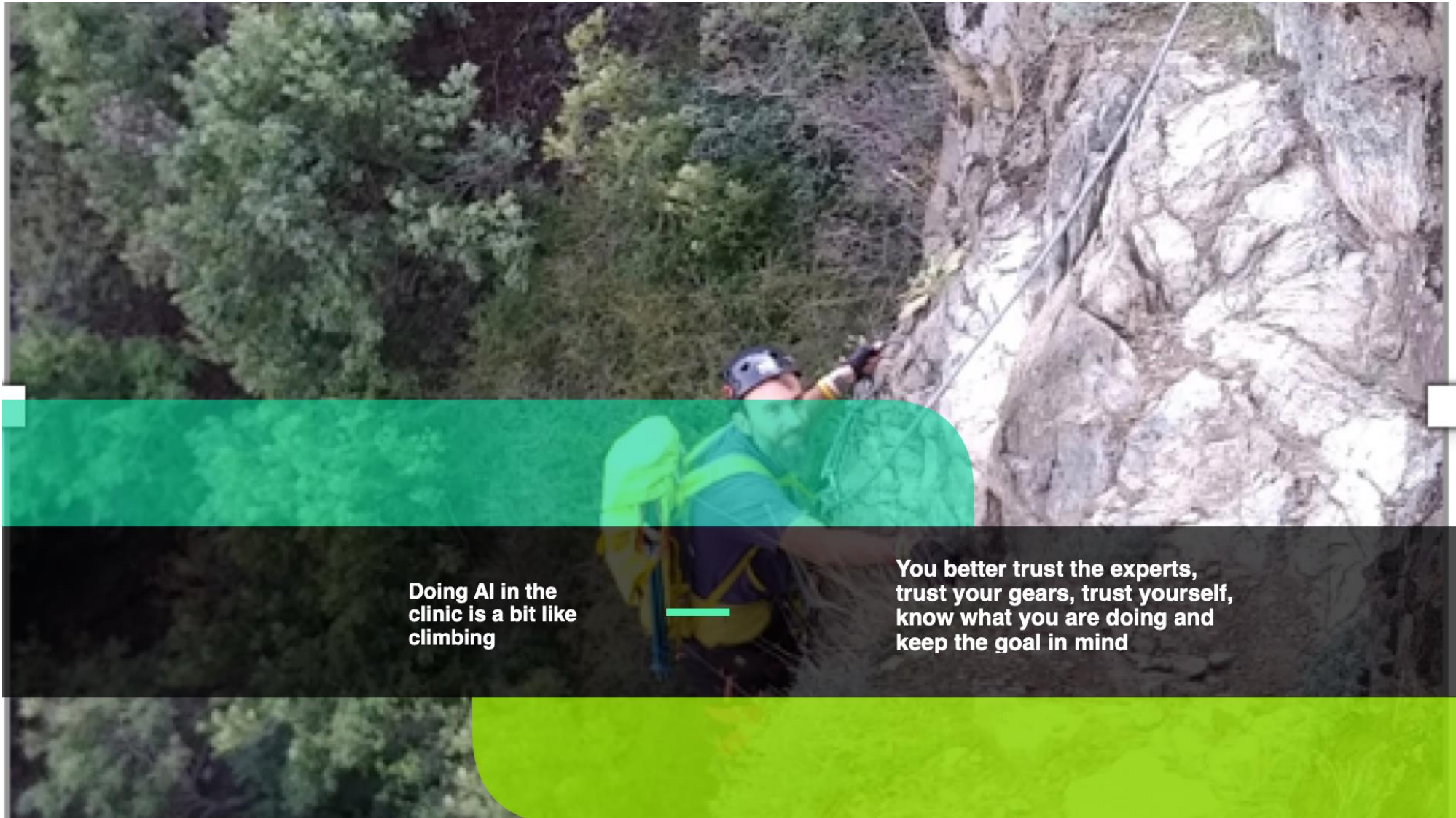
WHERE

Proposed solution: management



Bottom-up approach with feedback systems to align research with strategic needs

THANK YOU!



Doing AI in the clinic is a bit like climbing

You better trust the experts, trust your gears, trust yourself, know what you are doing and keep the goal in mind