AI and medical imaging

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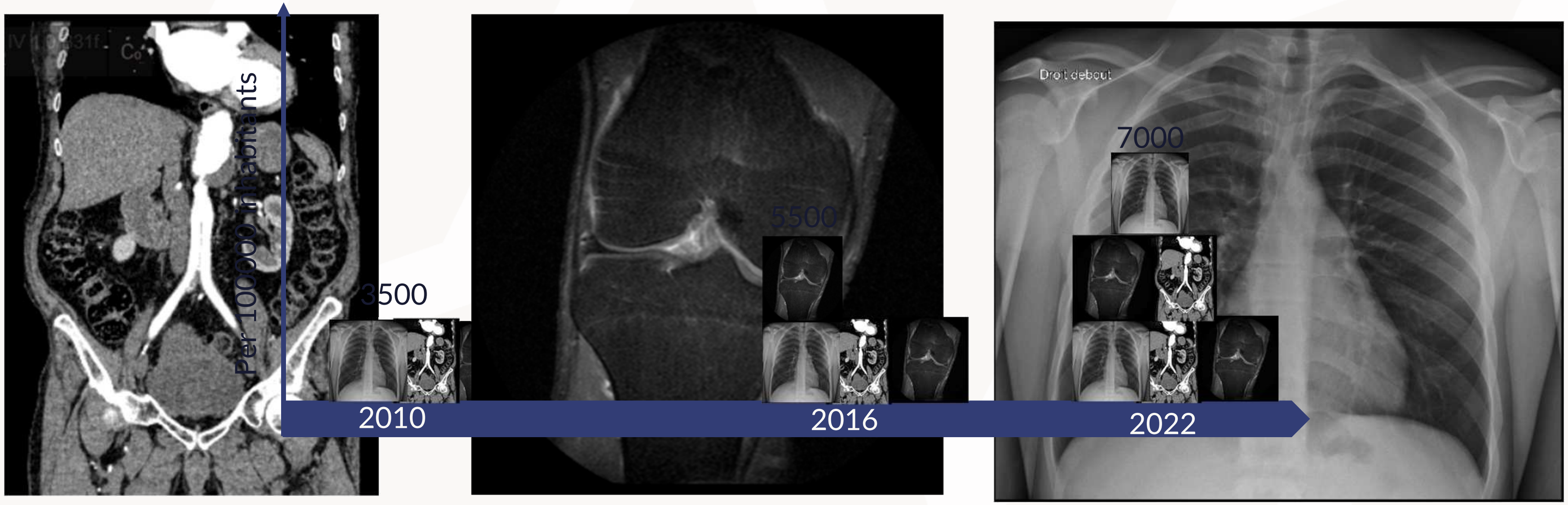
Saving time.
Saving lives.
Together.

Overview

- Introduction and context
- Addressing the lack of annotations: self-supervised learning approaches
- Application to prostate cancer detection

Introduction and context

- Medical examinations: images we are now quite familar with
- First MRI in France: 1984
- Since then: drastic increase in images amount

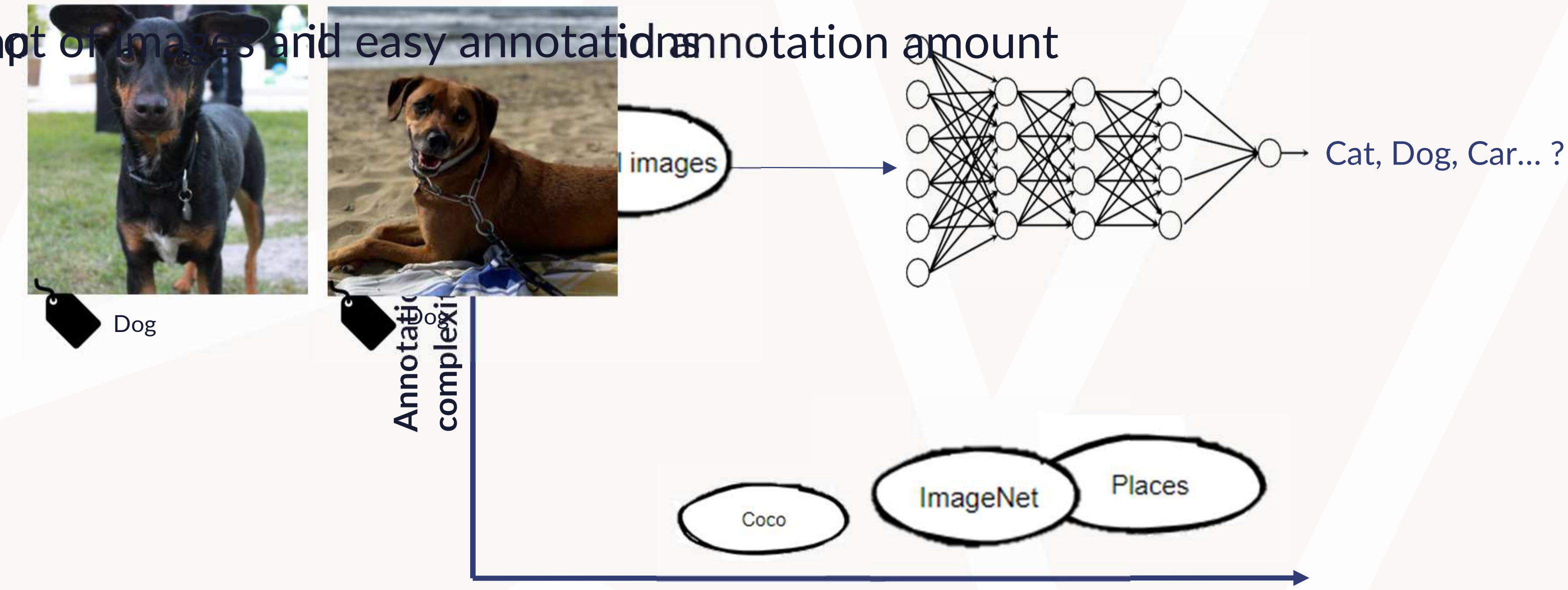


Source: https://data.oecd.org/fr/healthcare/

Introduction and context

- Data increase along with development of deep learning methods
- Natural images: ImageNet, CoCo, Places

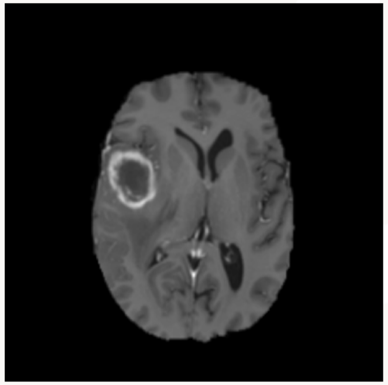
- A lot of images and easy annotations
- Gap in annotation amount



J. Deng, W. Dong, R. Socher, L.-J. Li, K. Li, and L. Fei-Fei. Imagenet: A large-scale hierarchical image database. In IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 248–255, 2009
Lin, Tsung-Yi et al. "Microsoft COCO: Common Objects in Context." *European Conference on Computer Vision* (2014).
B. Zhou, A. Lapedriza, A. Khosla, A. Oliva and A. Torralba, "Places: A 10 Million Image Database for Scene Recognition," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 40, no. 6, pp. 1452-1464, 1 June 2018

Introduction and context

Classification

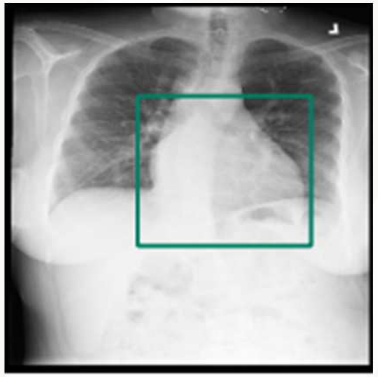


Healthy /
Pathological

Chest
pathology

< 2 minutes

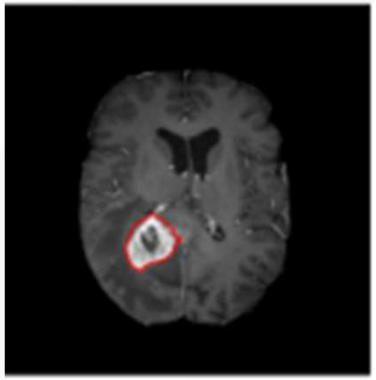
Localization



Box around region of
interest

~ 5/10 minutes

Segmentation

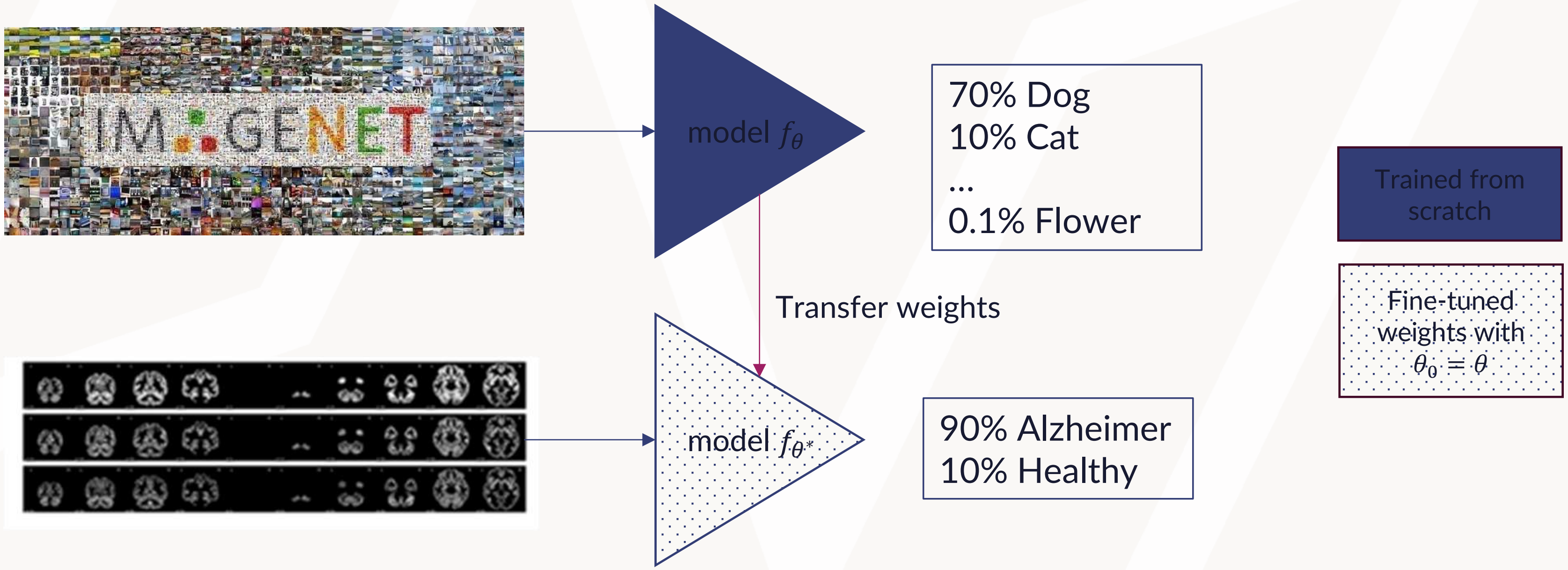


Pixel-wise contour of
pathology or organ

Up to 30 minutes

Introduction and context

Addressing the lack of annotations : supervised transfer learning



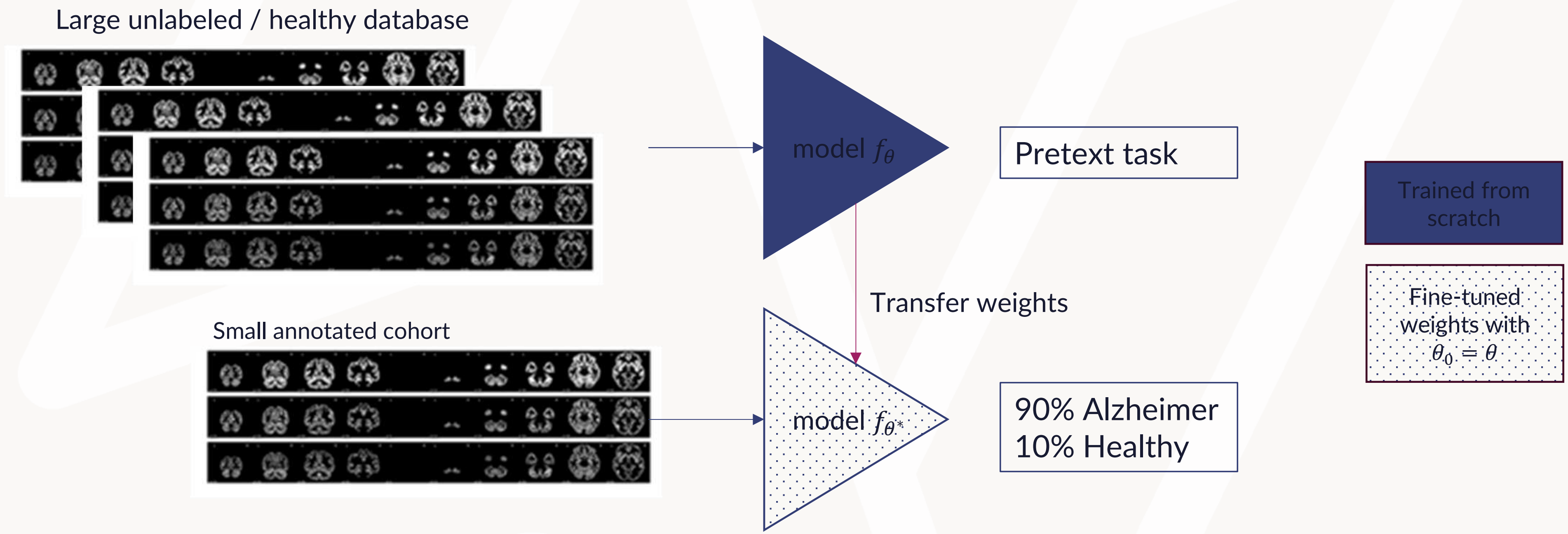
Introduction and context

Domain gap

- Visually dissimilar
- Medical images: smaller differences between classes
- Medical images can be 3D

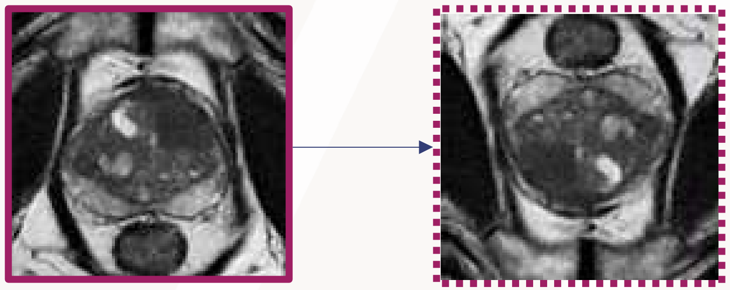
C. Matsoukas et al. “What Makes Transfer Learning Work for Medical Images”. In: CVPR. 2022.

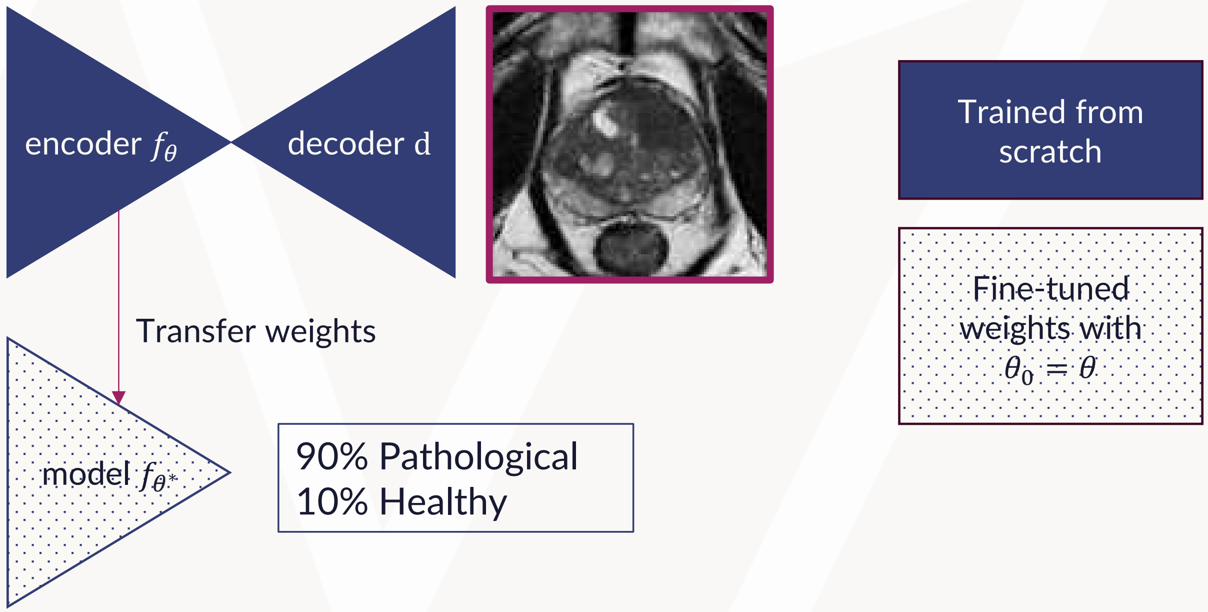
Introduction and context



Self-supervised learning approaches

Generation based self-supervised methods

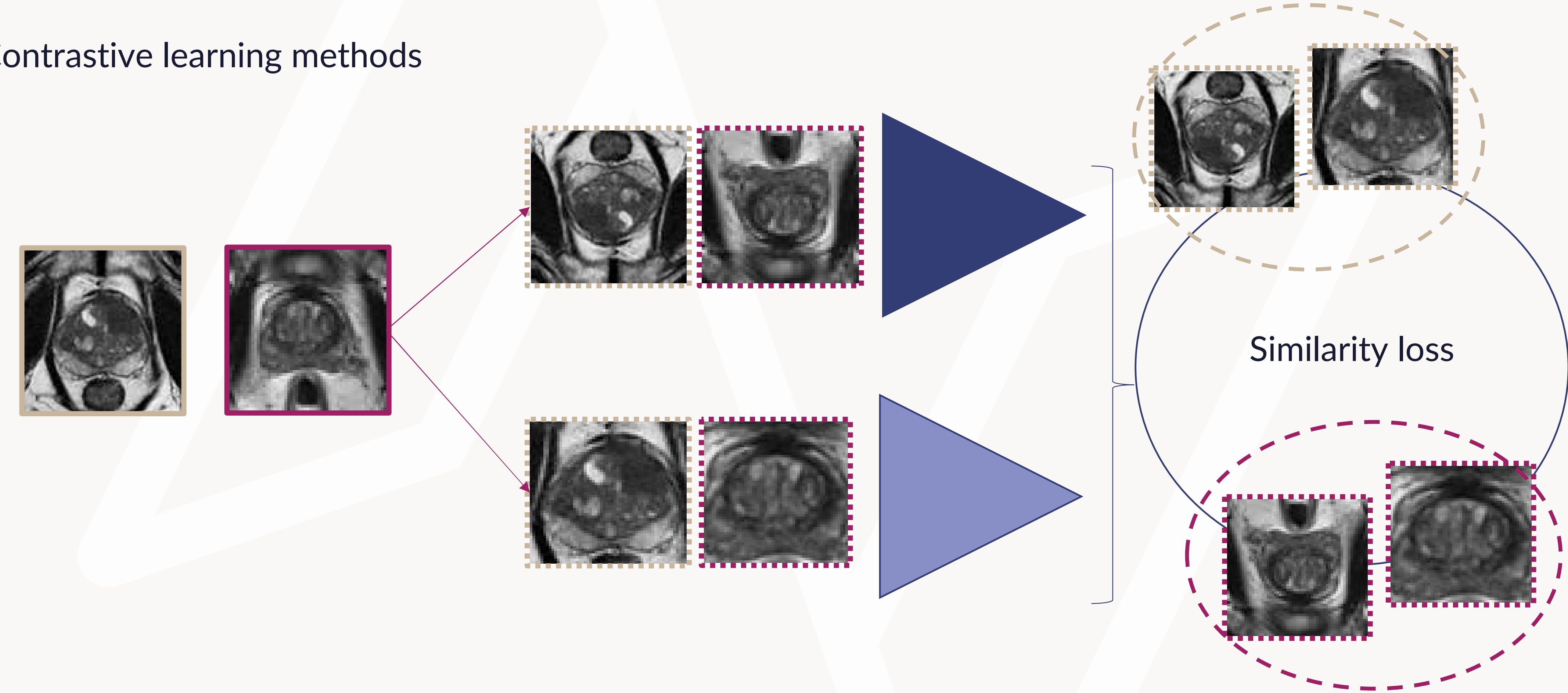




- Transformation types
- Link with target task

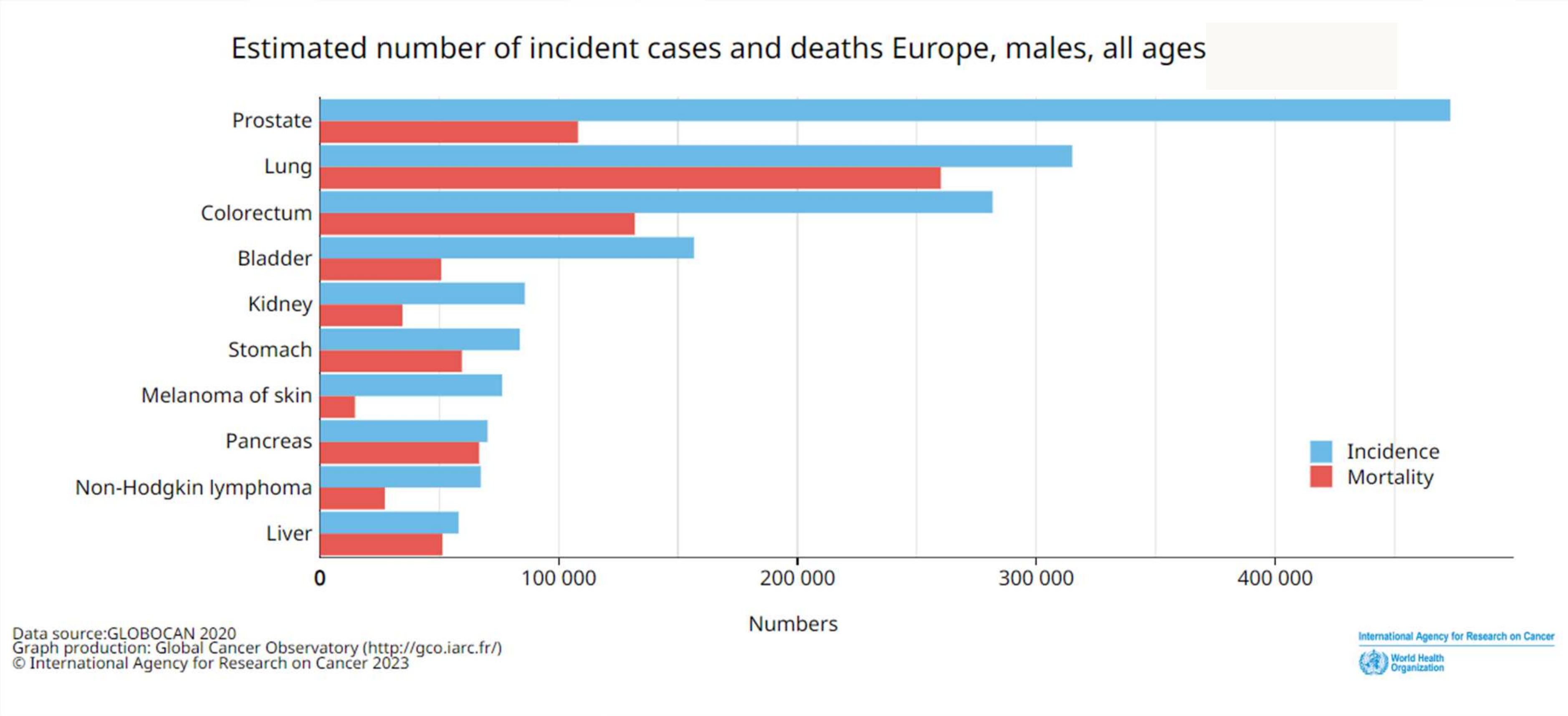
Self-supervised learning approaches

Contrastive learning methods

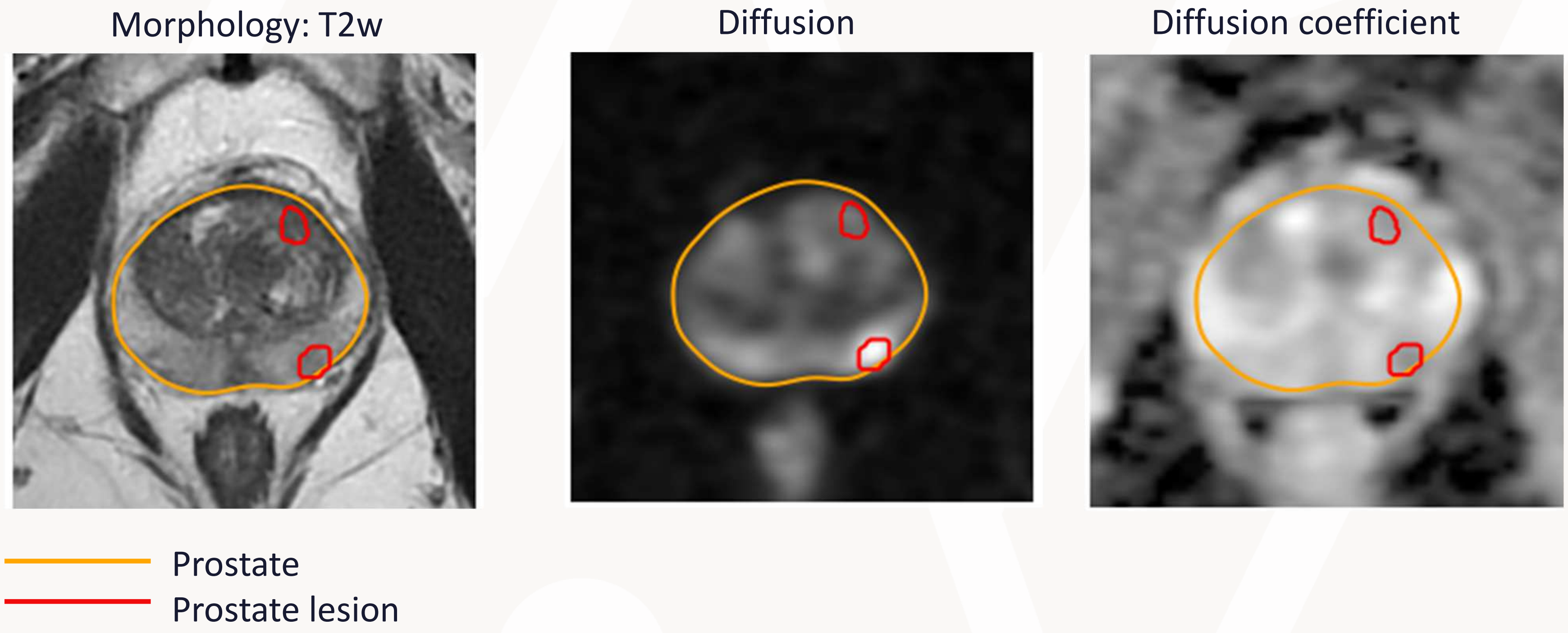


Application to prostate cancer detection

Most frequent cancer and cause of death from cancer in men



Application to prostate cancer detection



Application to prostate cancer detection

PI-RADS score
- lesion malignancy level, from 1 to 5
- High annotator variability

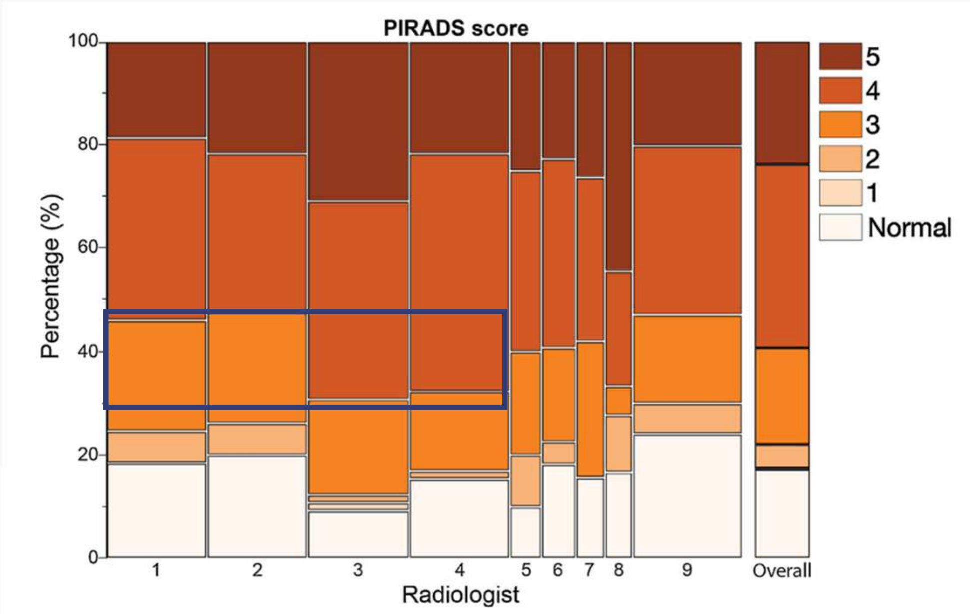
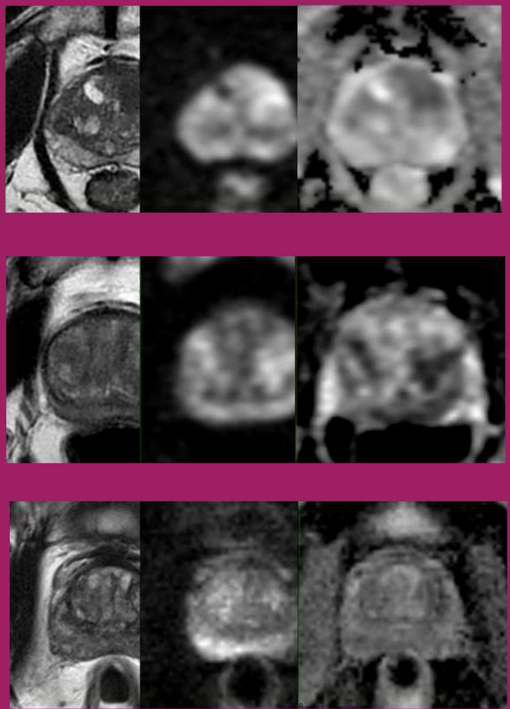


Figure from Sonn et al, Europeran Urology Foxus, 2019

Application to prostate cancer detection

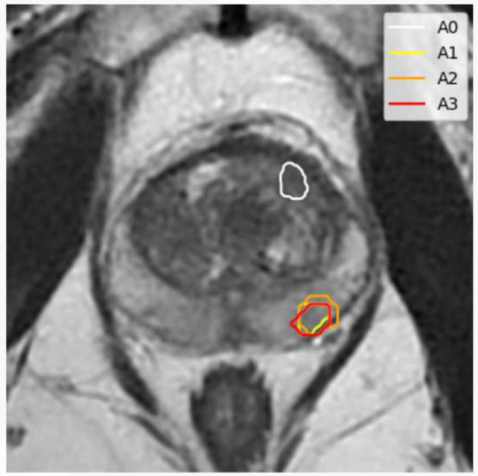


Multi modality MRI

Prostate segmentation

Lesion segmentation

- Access to multi-modality MRI
- Prostate segmentation
    - Easier task, less annotator variability [1]
- Manual lesion segmentation
    - More costly to obtain
    - More variability

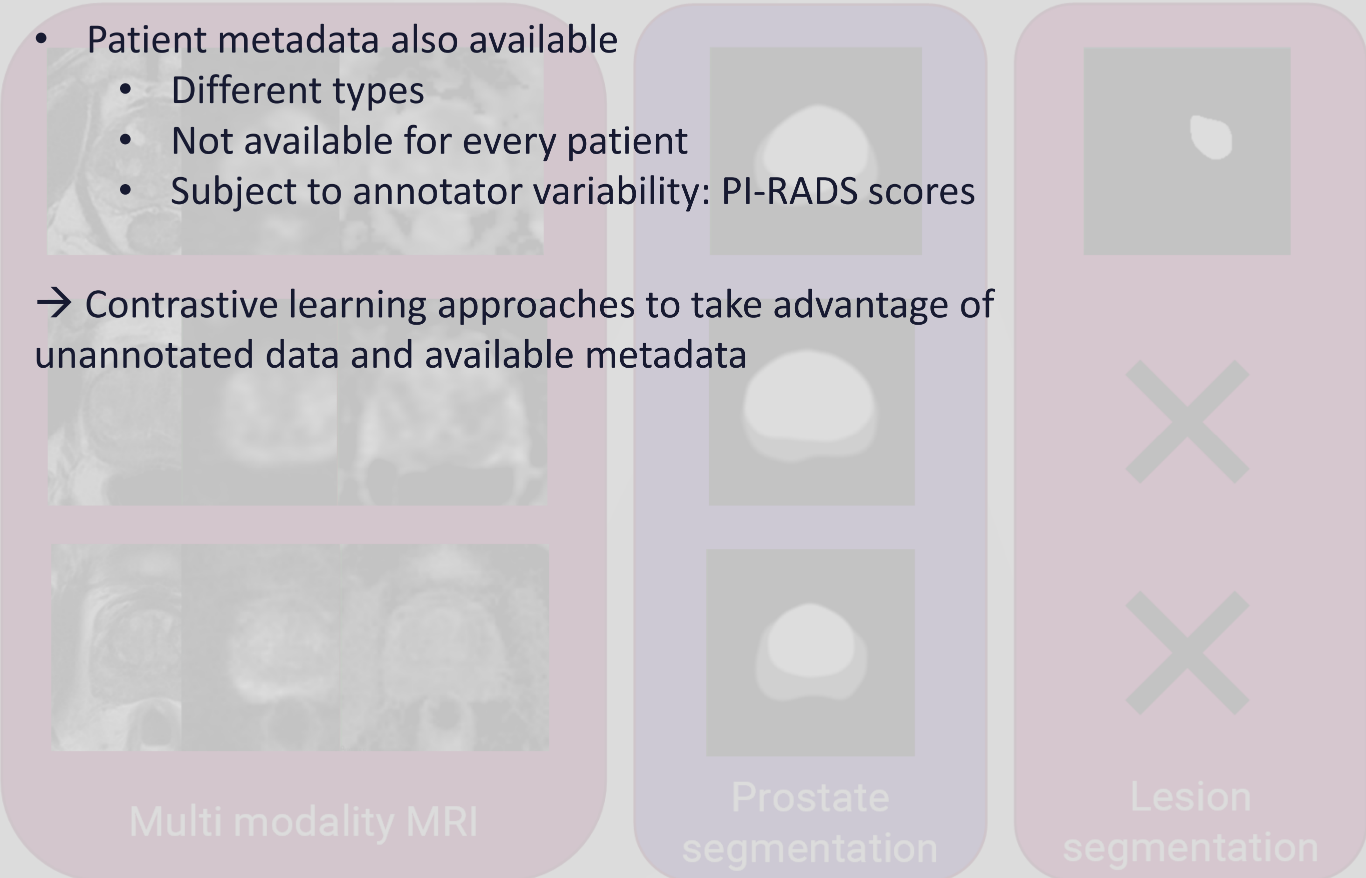


[1] Montagne, S., Hamzaoui, D., Allera, A. *et al.* Challenge of prostate MRI segmentation on T2-weighted images: inter-observer variability and impact of prostate morphology. *Insights Imaging* 12, 71 (2021)

Application to prostate cancer detection

- Patient metadata also available
  - Different types
  - Not available for every patient
  - Subject to annotator variability: PI-RADS scores

→ Contrastive learning approaches to take advantage of unannotated data and available metadata



- Lesion PIRADS score
- Patient's age
- Radiological report
- ISUP / Gleason scores

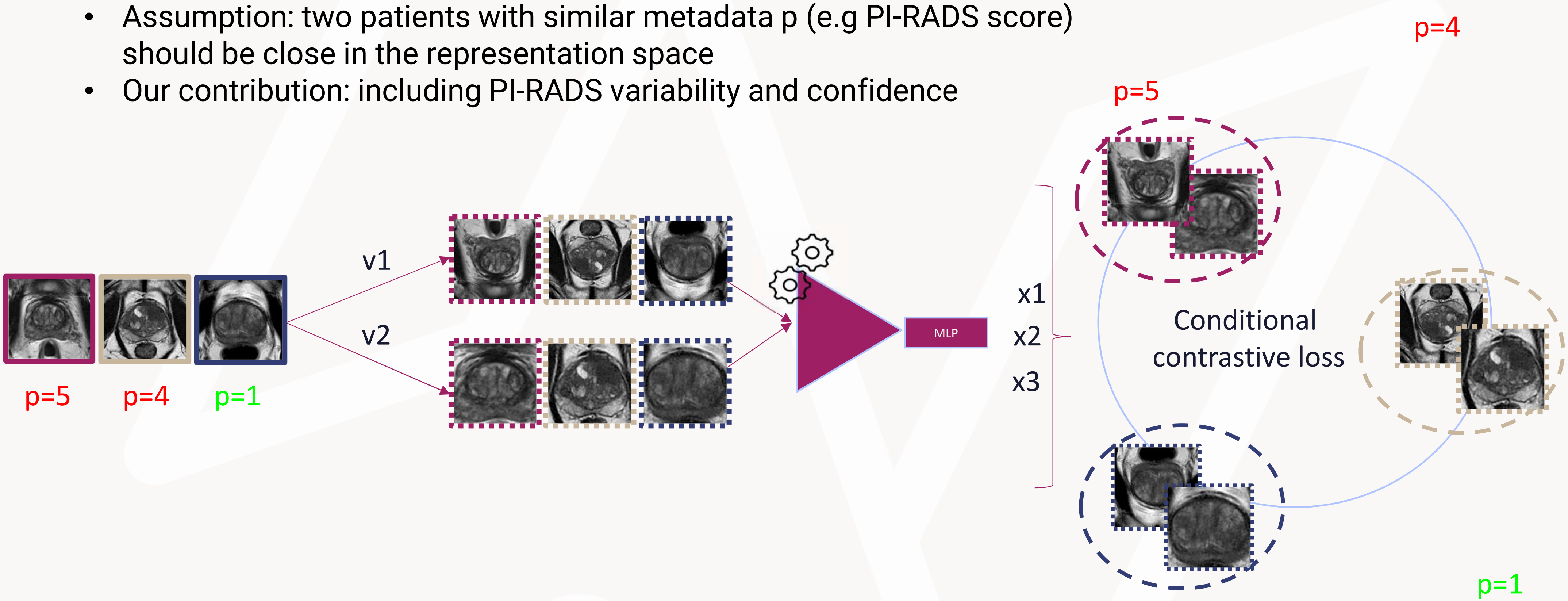
- Patient age
- PSA level
- Global PIRADS score from radiological report

- Patient's age
- Radiological report

Patient's metadata

Application to prostate cancer detection

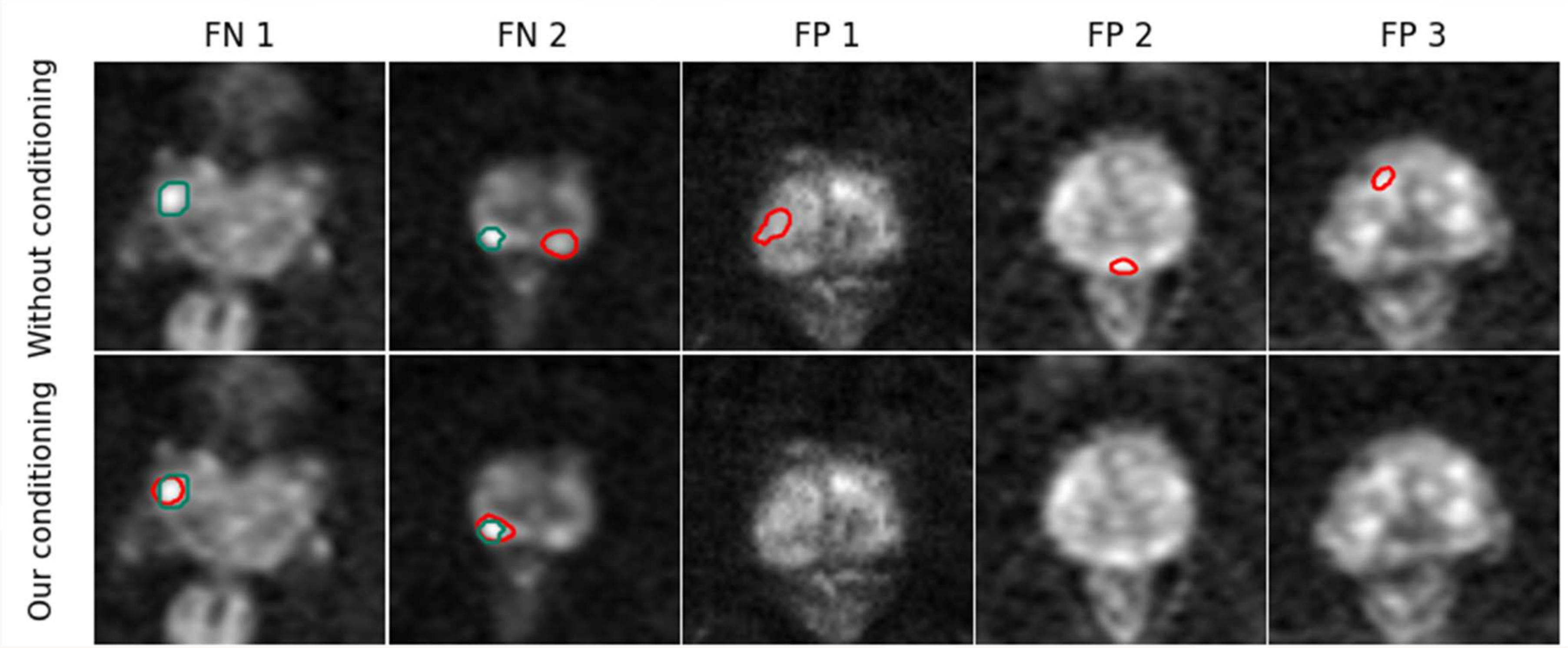
- Assumption: two patients with similar metadata p (e.g PI-RADS score) should be close in the representation space
- Our contribution: including PI-RADS variability and confidence



Dufumier, B., Gori, P., Victor, J., Grigis, A., & Duchesnay, E. (2021). Conditional Alignment and Uniformity for Contrastive Learning with Continuous Proxy Labels. *MedNeurIPS*

Application to prostate cancer detection

Reference segmentation
Predicted lesion



Conclusion

- Advent of neural networks on natural images with increased data availability
- Annotations much more complex to obtain in medical domain
- Self-supervised approaches: addressing the lack of annotations
- Promising results on prostate cancer detection taking variable metadata into account