



HAL
open science

PI-RADS Net: Une nouvelle méthode d'apprentissage profond pour la détection du cancer de la prostate cliniquement significatif à l'IRM

Kamilia Taguelmimt, Hong-Phuong Dang, Gustavo Andrade-Miranda, Dimitris Visvikis, Bernard Malavaud, Julien Bert

► To cite this version:

Kamilia Taguelmimt, Hong-Phuong Dang, Gustavo Andrade-Miranda, Dimitris Visvikis, Bernard Malavaud, et al.. PI-RADS Net: Une nouvelle méthode d'apprentissage profond pour la détection du cancer de la prostate cliniquement significatif à l'IRM. Colloque Français d'Intelligence Artificielle en Imagerie Biomédicale (IABM), Mar 2025, Nice, France. <hal-04992304>

HAL Id: hal-04992304

<https://hal.science/hal-04992304v1>

Submitted on 15 Mar 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

PI-RADS INSPIRED ARCHITECTURE: A NEW DEEP LEARNING APPROACH TO DETECT CLINICALLY SIGNIFICANT PROSTATE CANCER ON MRI

K. Taguelmimt[•] · H.-P. Dang^{•,*} · G. Andrade Miranda[•] · D. Visvikis[•] · B. Malavaud^b · J. Bert[•]

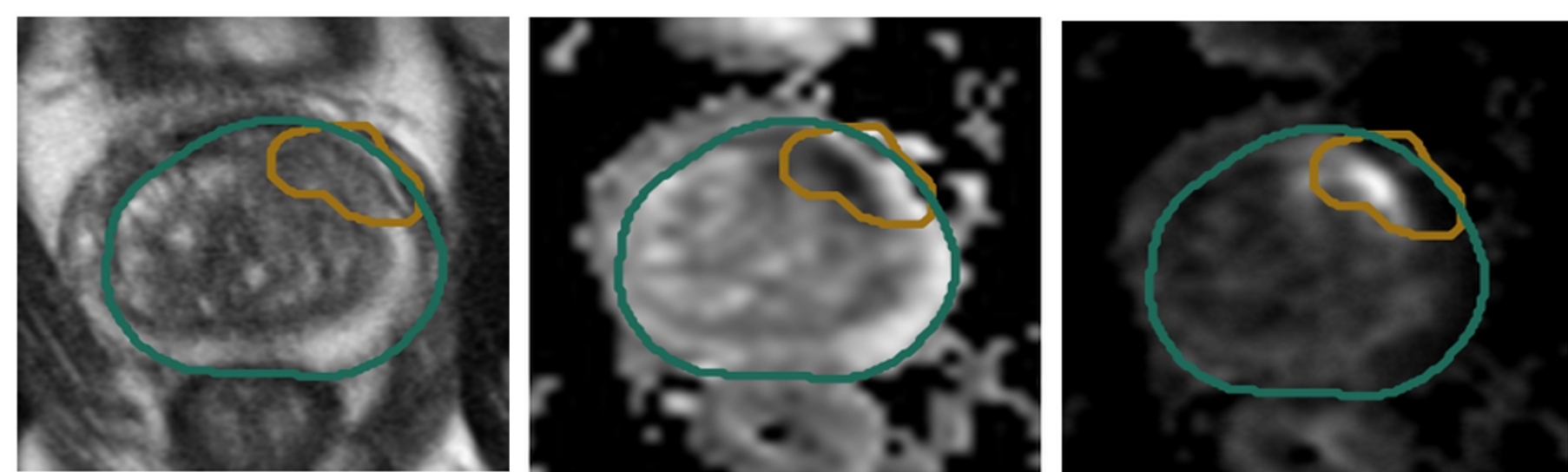
[•] LaTIM, UMR1101, INSERM, University of Brest, France

^{*} CentraleSupélec, IETR UMR CNRS 6164, Cesson-Sévigné, France

^b Toulouse Oncopole University Cancer Institute, France

ABSTRACT

Prostate cancer (PCa) is the most common cancer in men in 112 countries (15% of global cases). By 2040, cases are expected to rise from 1.4 to 2.9 million [1]. **Early detection**, through **multiparametric MRI (mpMRI)**, is key for better outcomes, but **manual MRI analysis** is **time-consuming** and prone to **errors** [2]. **AI-based computer-aided diagnostic (CAD)** tools aim to improve screening [3].



Prostate MRI images showing segmented lesions across different scans.

CONTRIBUTION We propose **PI-RADS-Net**, a deep learning model that emulates the **PI-RADS protocol** to detect **clinically significant PCa (csPCa)** [4]. Our approach holds promise for **improving the diagnosis** of clinically significant prostate cancer, **reducing unnecessary biopsies**, and **enhancing patient outcomes**.

PI-RADS-NET

We present **PI-RADS-Net**, a deep learning model inspired by the PI-RADS protocol to detect clinically significant prostate cancer (csPCa) on MRI. The model employs a two-branch architecture:

- **T2W** for the transition zone (TZ).
- **DWI + ADC** for the peripheral zone (PZ).

An extension, **PI-RADS-BimodalNet**, incorporates clinical parameters (PSA, prostate volume, age) using the TabNet framework to enhance classification performance [5].

EXPERIMENTS

Compared Models :

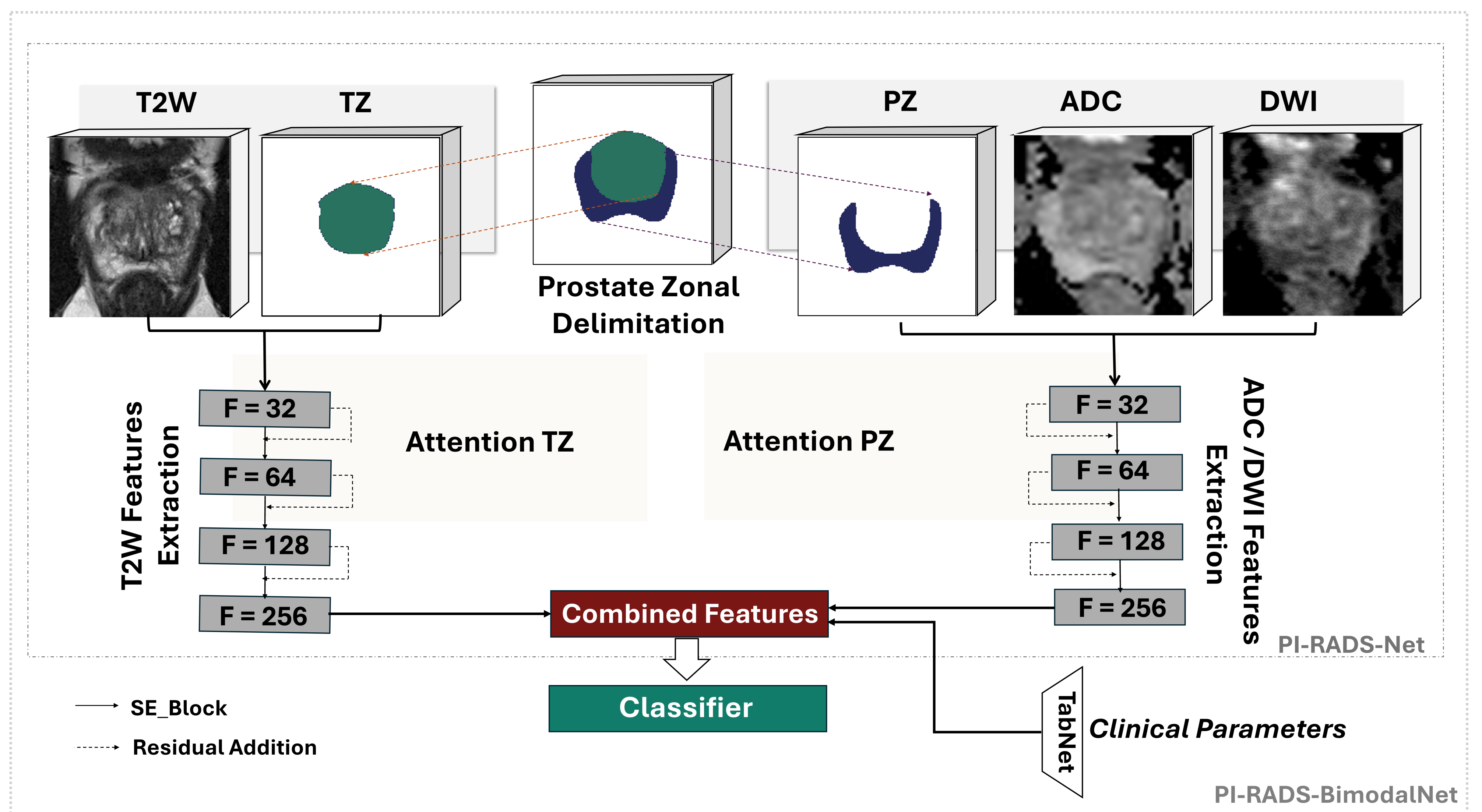
- **Unified-BranchNet**: A single-stream model combining all MRI sequences.
- **Bimodal-Unified-BranchNet**: Extends Unified-BranchNet by integrating clinical data.
- **DenseNet121 & ResNet50**: Deep architectures used as benchmarks.

Data Collection & Processing (PICA Database): 1,295 MRI scans (1,075 benign/indolent, 220 csPCa); preprocessing: alignment, cropping, resampling (144×144×32 voxels, 0.5×0.5×0.3 mm), Min-Max normalization; prostate segmentation via nnU-Net (Dice: 0.8968 ± 0.0547). The data was split 80/20 with 5-fold cross-validation.

REFERENCES

- [1] N. e. a. James, "The lancet commission on prostate cancer: planning for the surge in cases," *The Lancet*, vol. 403, no. 10437, pp. 1683–1722, 2024.
- [2] J. e. a. Fütterer, "Can clinically significant prostate cancer be detected with multiparametric magnetic resonance imaging? a systematic review of the literature," *Eur. Urol.*, vol. 68, no. 6, pp. 1045–1053, 2015.
- [3] R. e. a. Cuocolo, "Machine learning applications in prostate cancer mri," *Eur. Radiol. Exp.*, vol. 3, no. 1, pp. 1–8, 2019.
- [4] B. e. a. Turkbey, "Prostate imaging reporting and data system version 2.1: 2019 update," *Eur. Urol.*, vol. 76, no. 3, pp. 340–351, 2019.
- [5] S. Ö. Arik and T. Pfister, "Tabnet: Attentive interpretable tabular learning," in *Proc. AAAI Conf Artif. Inte.*, 2021.

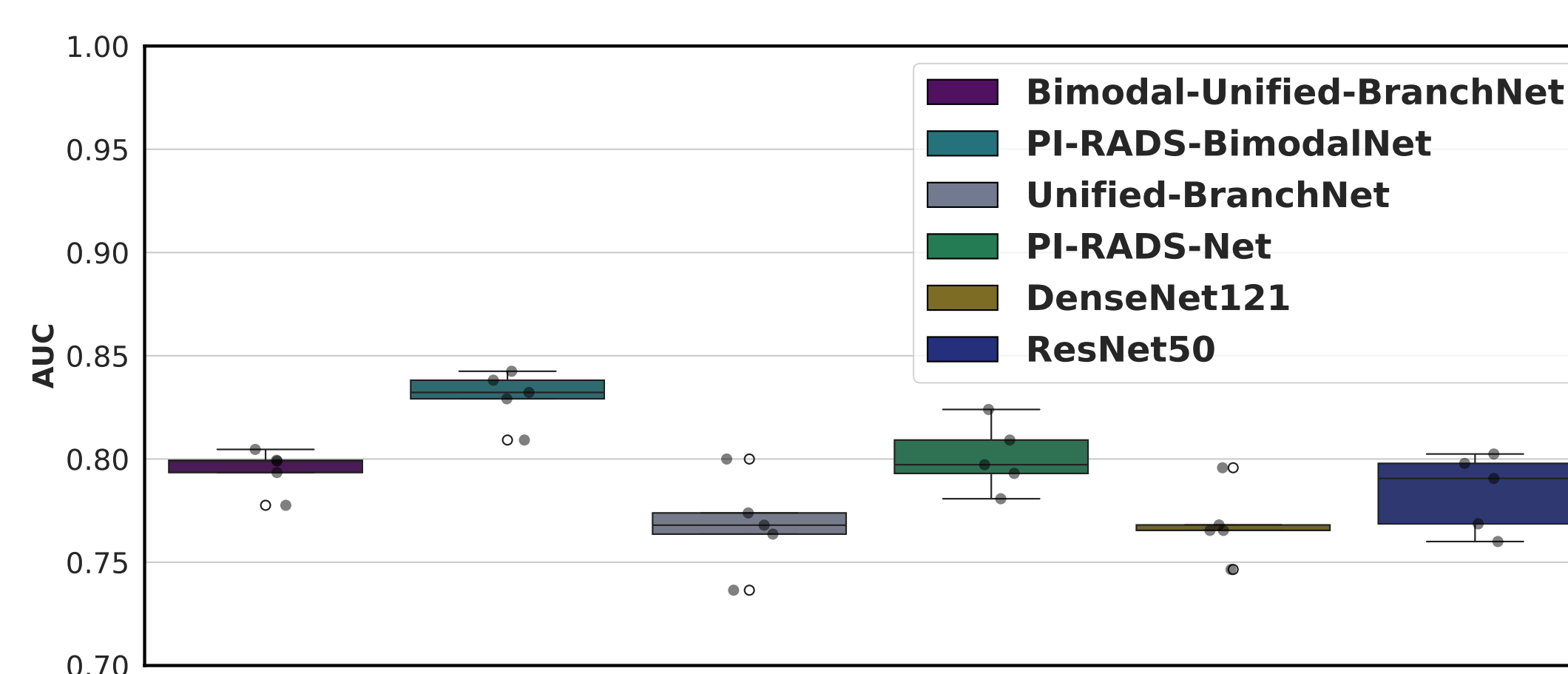
METHODOLOGY



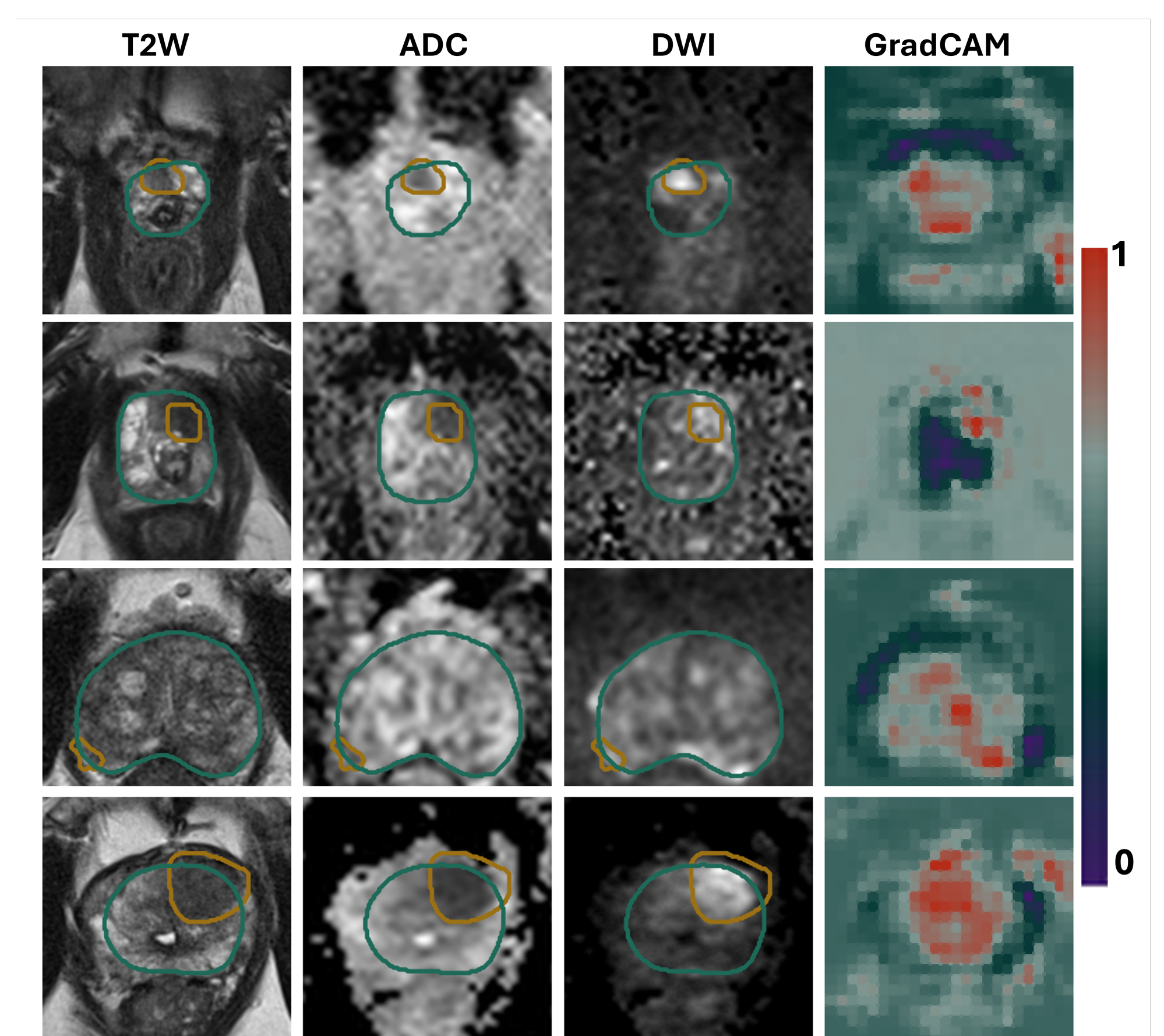
PI-RADS architectures feature a two-branch design: one processes T2W sequences for the TZ, while the other handles ADC/DWI sequences for the PZ. Both use convolutional blocks with SE (Squeeze and Excitation) modules and residual connections. In bimodal PI-RADS-BimodalNet, clinical data are integrated via TabNet with combined features and passed to a classifier to detect csPCa.

RESULTS & DISCUSSION

| Model | AUC | Sens. | Spec. | Acc. |
|----------------------------------|-------------|-------|-------------|-------------|
| Bimodal-Unified-BranchNet | 0.80 | 0.84 | 0.67 | 0.69 |
| PI-RADS-BimodalNet | 0.83 | 0.73 | 0.72 | 0.72 |
| Unified-BranchNet | 0.80 | 0.75 | 0.73 | 0.73 |
| PI-RADS-Net | 0.82 | 0.68 | 0.84 | 0.81 |
| DenseNet121 | 0.80 | 0.61 | 0.77 | 0.74 |
| ResNet50 | 0.80 | 0.77 | 0.71 | 0.72 |



- **PI-RADS-Net** (average AUC 0.80) outperforms Unified-BranchNet (0.77), proving PI-RADS benefits.
- Adding clinical data boosts **PI-RADS-BimodalNet** to average AUC 0.83 (+3.75% vs. PI-RADS-Net).



- **The bimodal** approach increases average sensitivity by 10.4% (0.67→0.74), improving lesion detection.
- **Grad-CAM** shows the key regions influencing the model's decisions.

CONCLUSION & OUTLOOK

- This study shows that integrating multi-sequence MRI (T2W, ADC, DWI) in PI-RADS-Net enhances classification, and extending it with clinical data in PI-RADS-BimodalNet further improves performance and stability.
- Future work should refine PI-RADS-BimodalNet by incorporating additional clinical parameters, optimizing attention mechanisms, validating on external datasets, and addressing diagnostic uncertainty for improved robustness and clinical applicability.

ACKNOWLEDGEMENTS & CONTACTS

This work was partly supported by the French State under the Future Investments Program through the DIANA project (PSPC-DIANA-2021 BPI) and by France Life Imaging (grant ANR-11-INBS-0006). ✉ kamilia.taguelmimt@univ-brest.fr