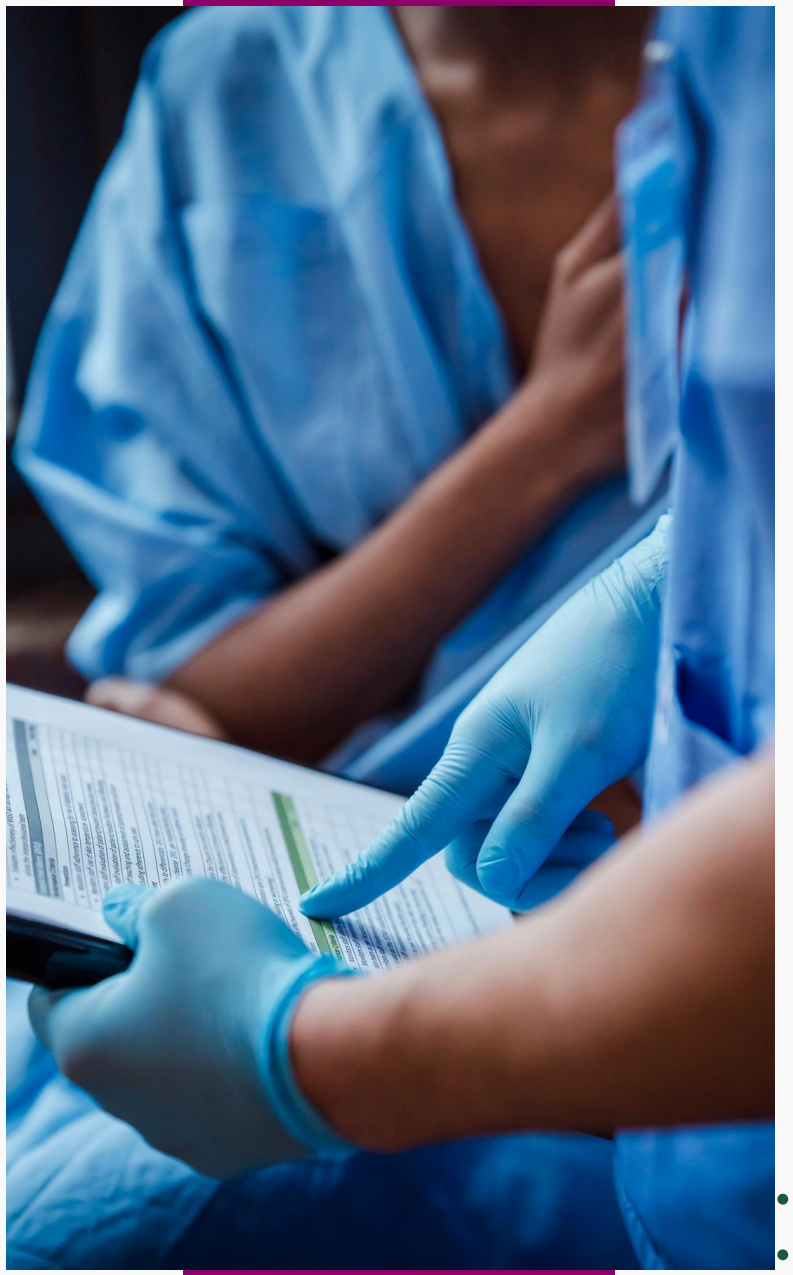
UNIVERSITY OF PORTSMOUTH

Innovative Approaches to Prostate Biopsy Decision-Making: A Machine Learning and Optimization Framework



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Research Project Overview

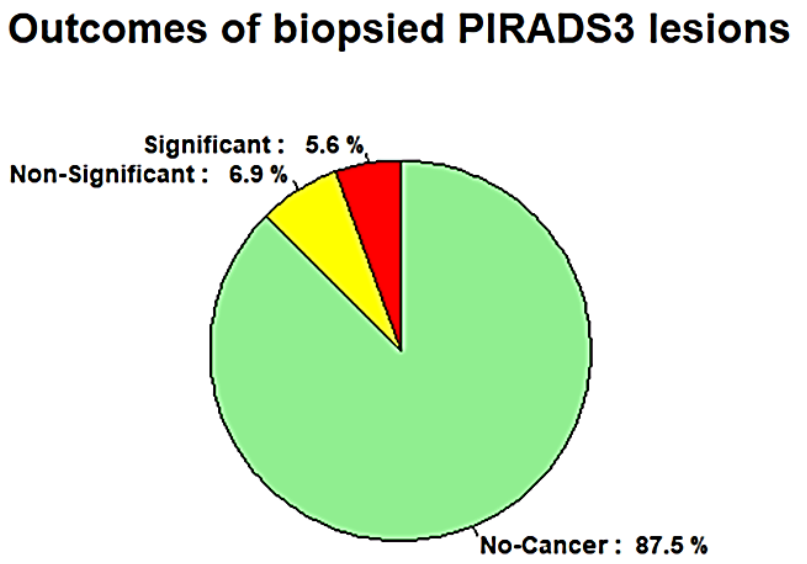
- **Complexity** and **inefficiencies** in booking system
- **Repeated** biopsies
- Needs for a **consistent** approach

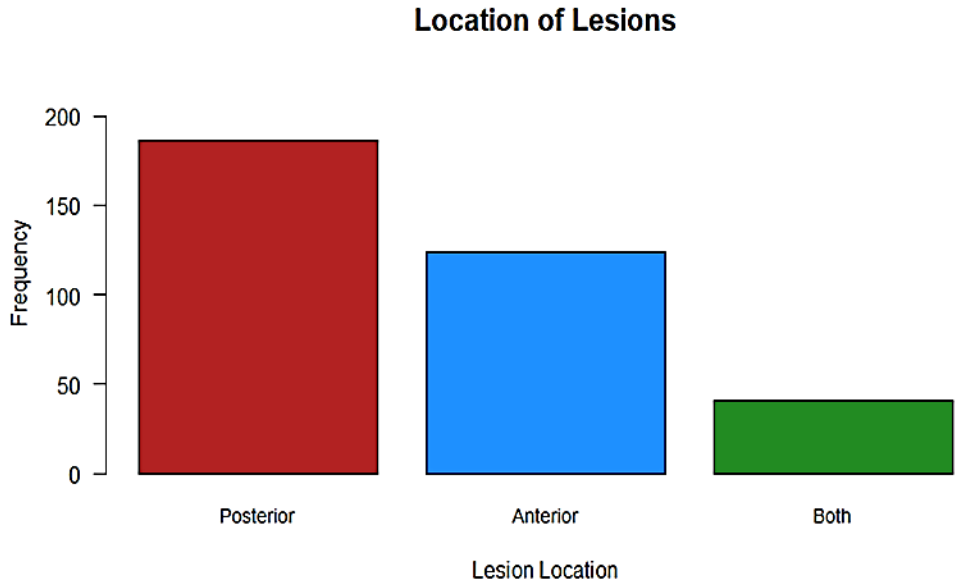
- **Literature Review**
- **Exploratory Data Analysis**:
  - 2018-2024
  - Dataset A : n=2323
  - Dataset B : n=1104 (extracted = 303)
- Mathematical modelling and **optimization**
- **Machine Learning** Models

A Data-Driven Decision Support System that optimizes and personalizes prostate biopsy decisions

Whether to biopsy PIRADS-3 patients or not?

- **PSA: No significant difference** between the PSA levels of patients with no cancer and those of clinically significant cancer.
- **Prostate Volume:** Patients **with cancer** have lower mean **(55.5 vs 71)** and median **(46.5 vs 64).**
- **PSA Density:** Patients with cancer have higher PSA Density values. PSA Density values above **0.13** are associated with a higher likelihood of cancer.
- **Lesion Size:** There is **no significant difference** between the lesion sizes for patients with and without cancer.



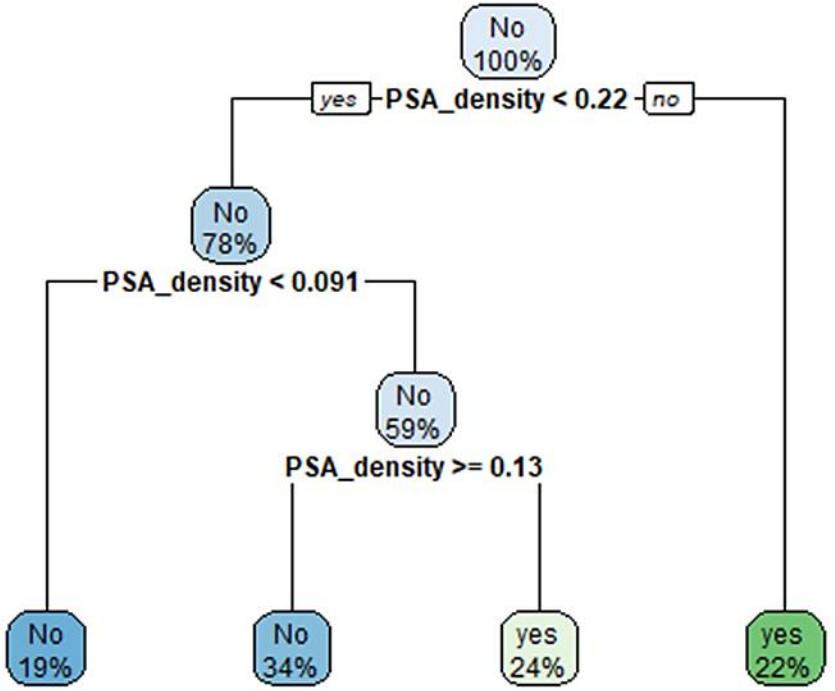


Machine learning models: When to biopsy PIRADS-3 patients?

- In all machine learning algorithms **PSA density** was the most important feature differentiate clinically significant and insignificant cancers.

- The PSA density threshold in the decision-tree model (**0.13**) is close to the recent EAU guideline (**0.10**).

	Accuracy	95% CI	Sensitivity	Specificity
Random Forest	0.8462	(0.7764, 0.901)	0.8684	0.8209
Bagged CART	0.8629	(0.7896, 0.9181)	0.8955	0.8246
Boost Classification Trees	0.6935	(0.6044, 0.7732)	0.7015	0.6842
KNN	0.8871	(0.8178, 0.9369)	0.8806	0.8947
Logistic Regression	0.6783	(0.5951, 0.7539)	0.7500	0.5970

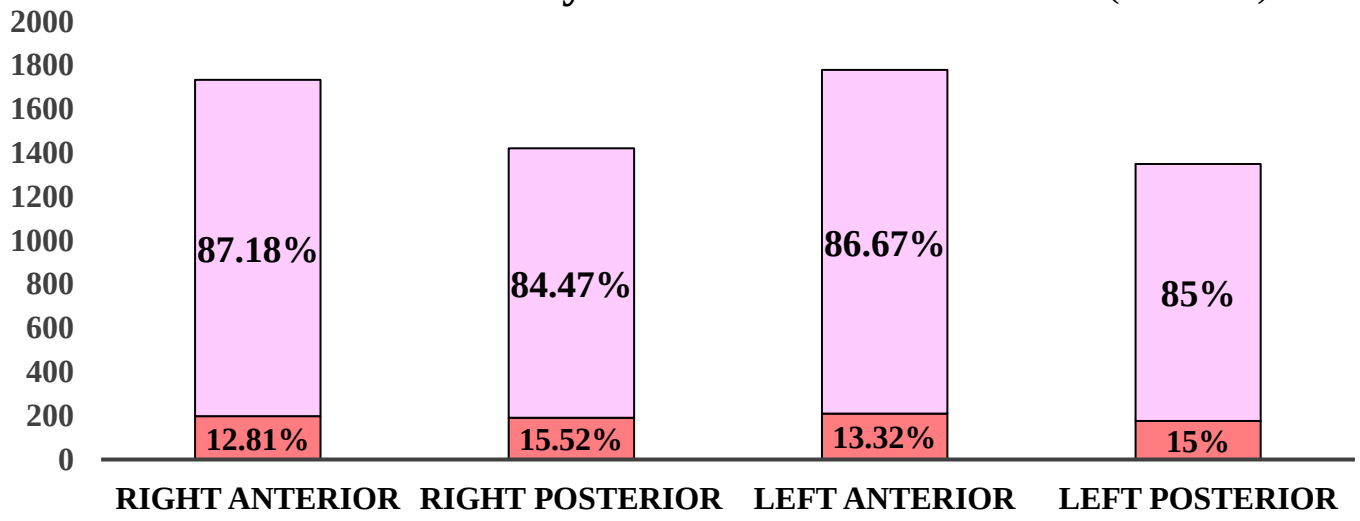


What is the contribution of Systematic Biopsy cores?

- **Dataset A**
  - Systematic cores diagnosed cancer in **9% of all patients**.
  - **PI-RARDS 2 patients:**
    - Systematic biopsies diagnosed cancer in **38.46%** of PI-RADS 2 cases.
    - PSA density levels greater than **0.20** are associated with a **higher** probability of cancer (in line with the recent **EAU guideline** recommendation which is **0.20**).

- **Dataset B**
  - **5.60%** of patients diagnosed by systematic biopsy.

contribution of systematic cores for lesions (dataset B)

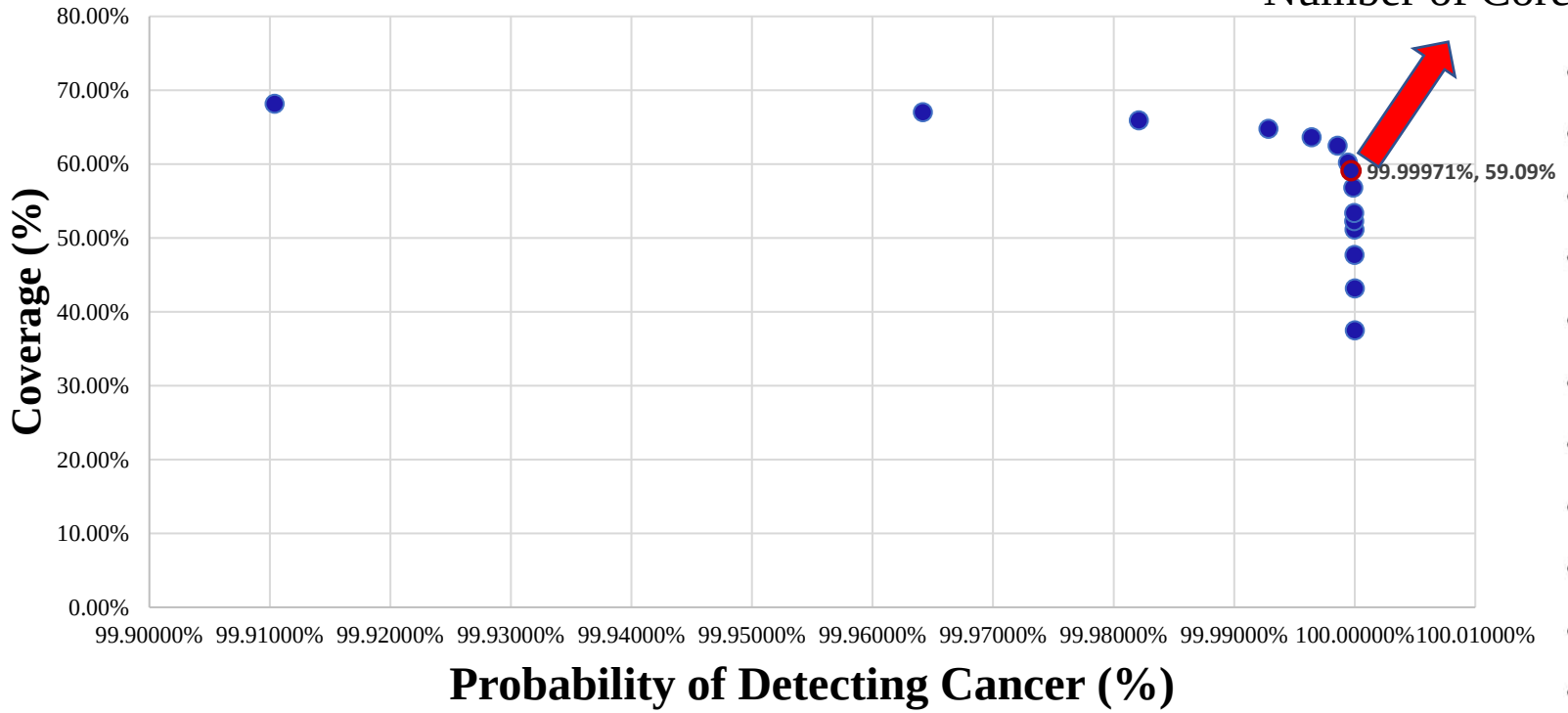


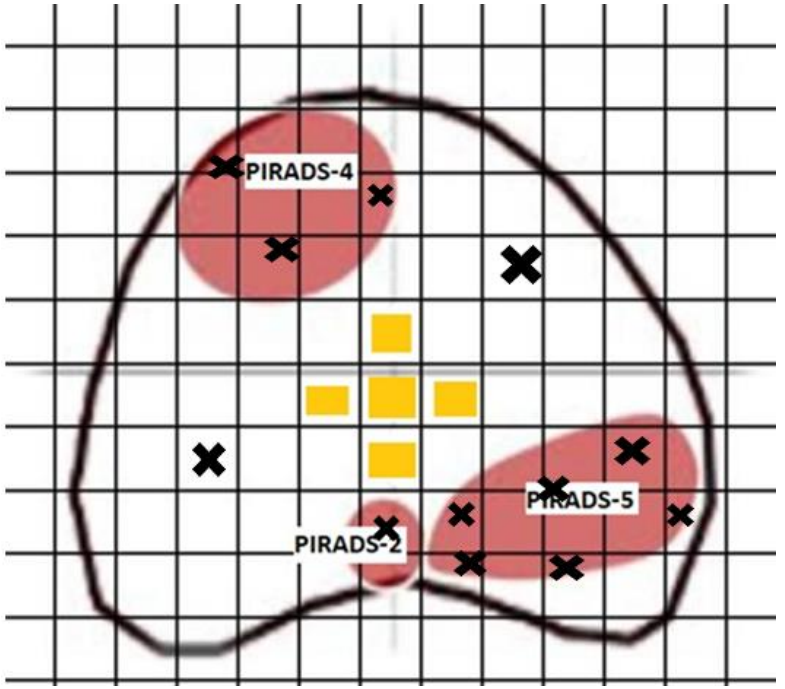
How to personalise the biopsy sampling plan?

A multi-objective optimization model that maximises:

- The **probability of detecting cancer**
- The **coverage**

Number of Cores: TB (10), SB(2)





CONCLUSIONS

- An ongoing project that aims to develop a decision support system which will help:

  - Reduce **complexities** and **inefficiencies** in the booking system
  - Guide the healthcare professionals in **personalising biopsy plans**
  - Maximise the detection of clinically **significant PCa**
  - Minimise **overdiagnosis** – detection of clinically insignificant PCa