Pontificia Universidad Católica de Chile
Facultad de Física
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Study on Prostate Cancer using Magnetic Resonance Images information and using AI tools

Development of a model to predict risk group of prostate cancer and Automatic Segmentation

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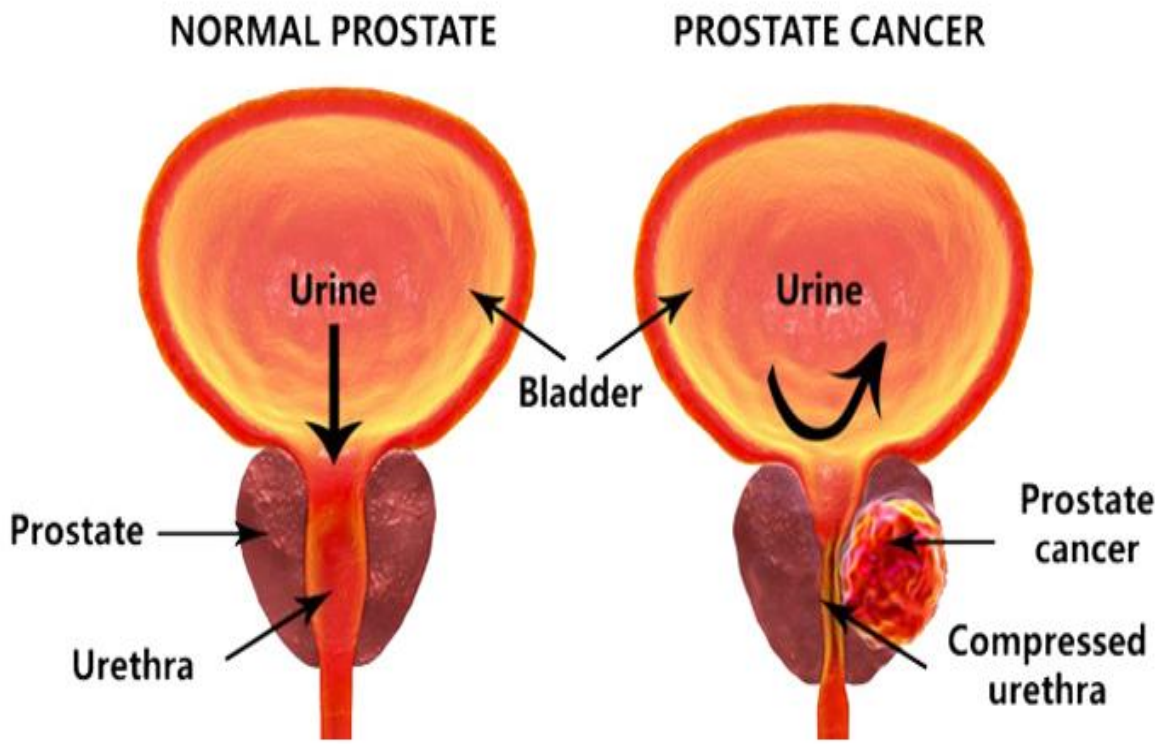
Collaborator: José Dominguez

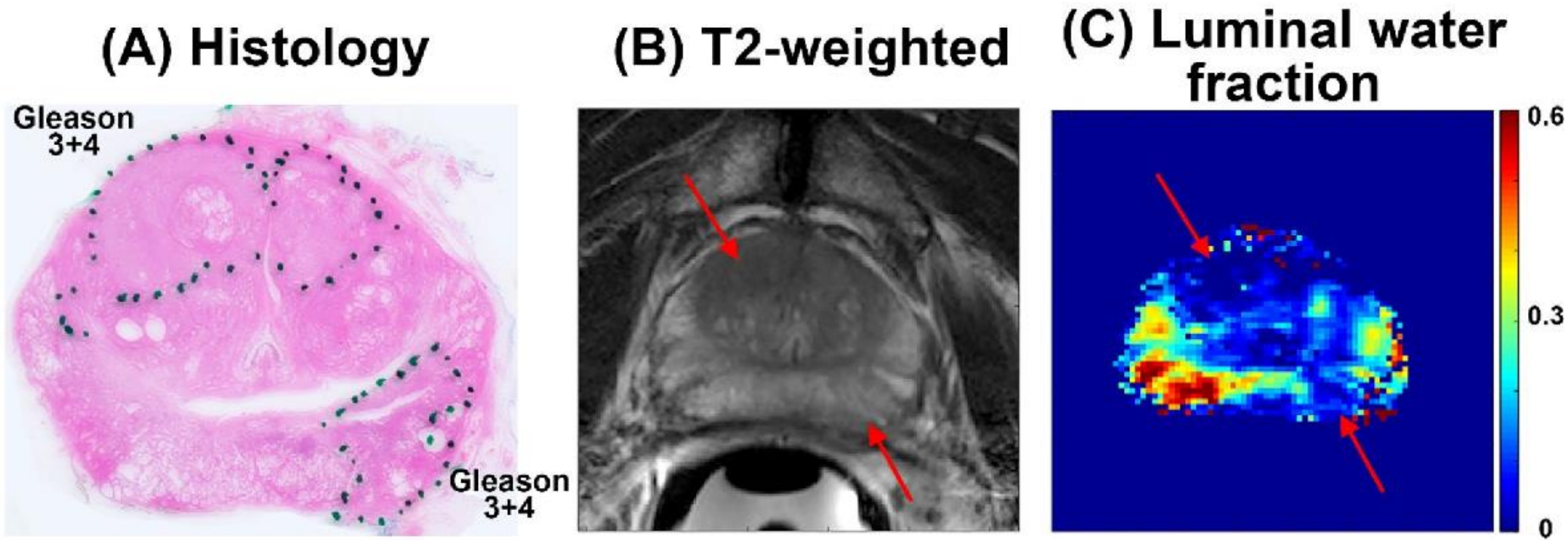
Outline

1. Development of a model based on magnetic resonance images information and automatic learning tools to predict risk group of prostate cancer

2. Detection and automatic segmentation of intraprostatic Lesions using Deep Learning Tools

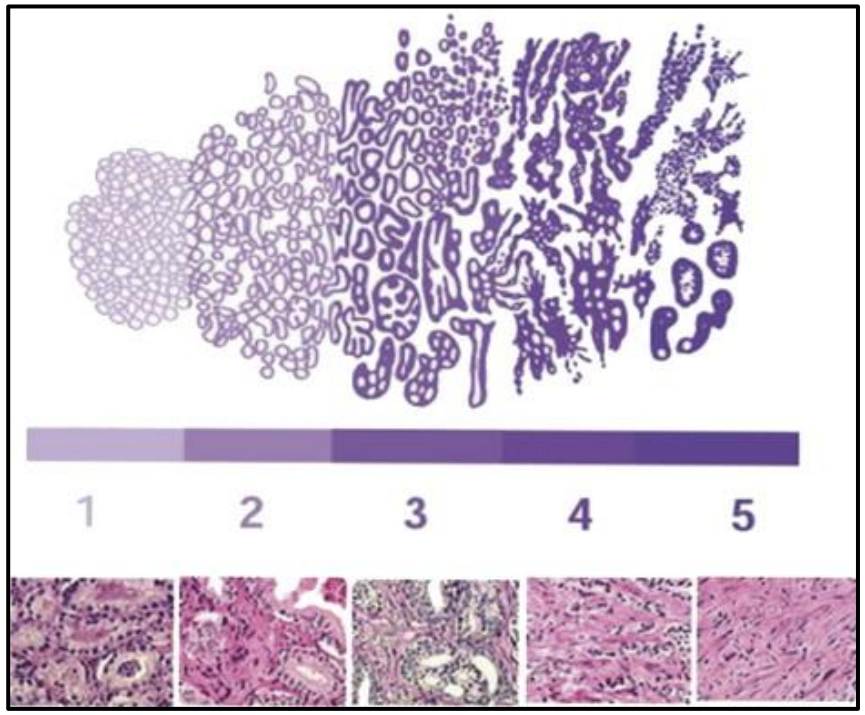
Prostate and Prostate Cancer (PCa)





71-year-old patient with Gleason grade 3 + 4 cancers in the left peripheral zone and anterior transition zone (arrows). (a) Histological image, (b) T2-weighted image and (c) luminal water fraction map are shown. Cancers are characterized by reduced luminal water fraction compared to surrounding benign prostatic tissue (Aritrick C. et al. (2020))

Gleason Score and Risk Group



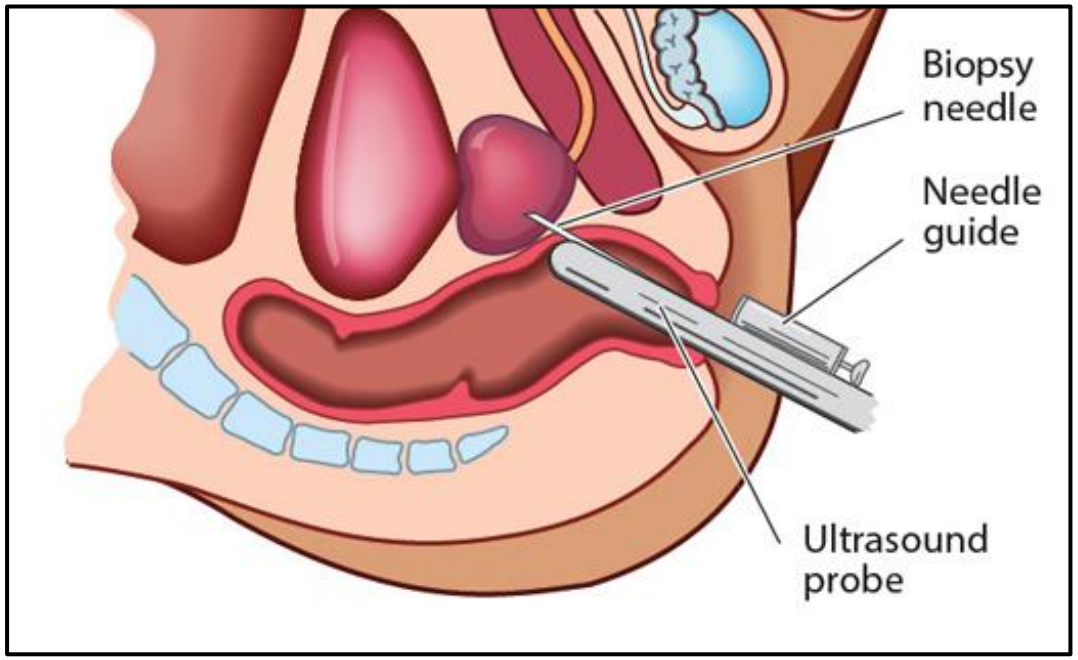
Picture of tissue cells under the microscope. Image from Harden et al. (2007).

Risk Group*	Grade Group	Gleason Score
Low/Very Low	Grade Group 1	Gleason Score ≤ 6
Intermediate (Favorable/Unfavorable)	Grade Group 2	Gleason Score 7 (3 + 4)
	Grade Group 3	Gleason Score 7 (4 + 3)
High/Very High	Grade Group 4	Gleason Score 8
	Grade Group 5	Gleason Score 9-10

Table with the grading scores of GS, the grade groups and their corresponding risk group. From Prostate cancer Foundation.

1. Development of a model based on magnetic resonance images information and automatic learning tools to predict risk group of prostate cancer

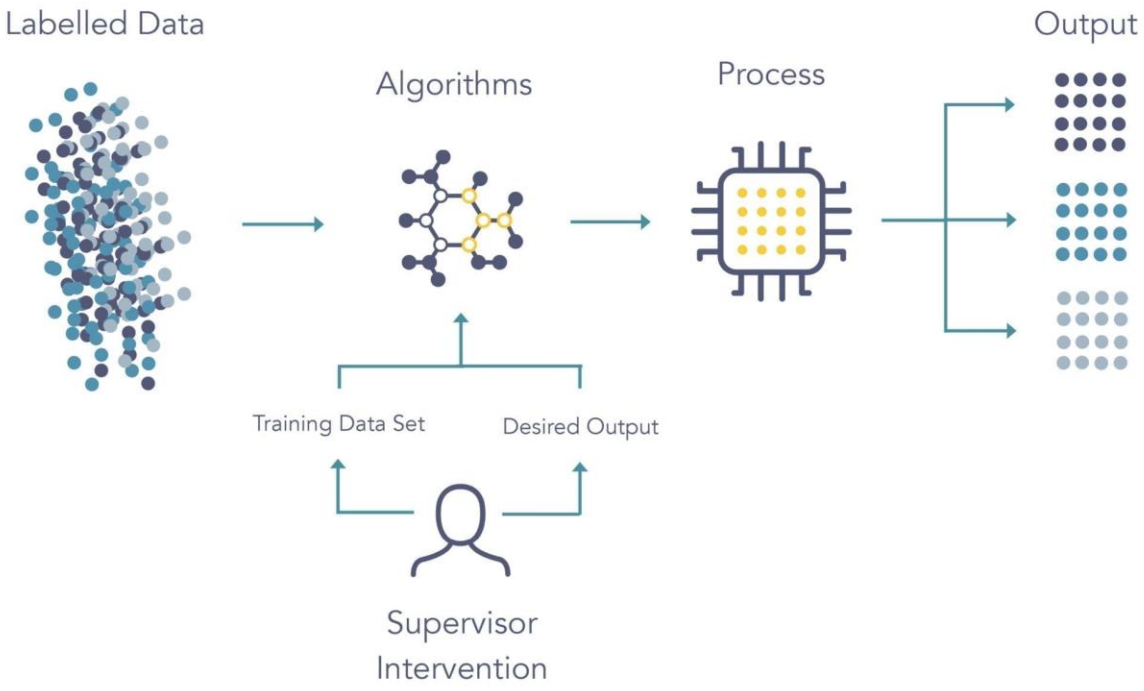
Motivation and Objective



- Finding an accurate grading and categorization of the prostate cancer for the selection of a **suitable treatment and reducing prostate cancer morbidity and mortality.**
- **Developing a potential model** for automatic stratification, including different kinds of features.

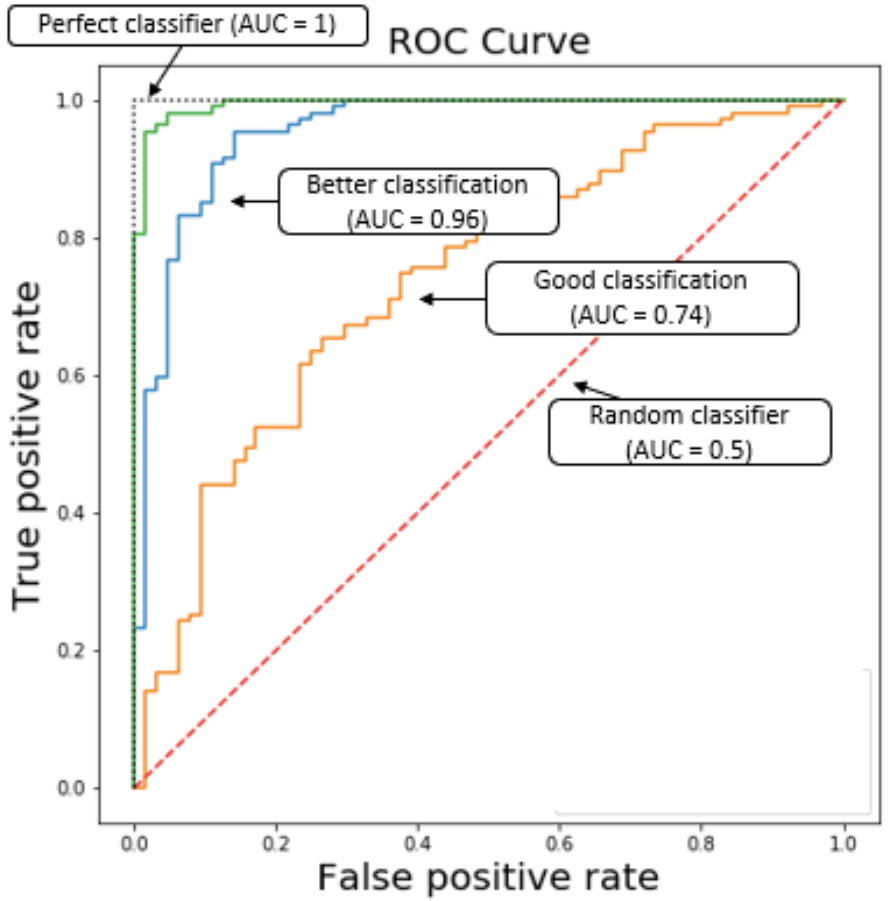
Automatic Learning

Supervised Machine Learning



Scheme of the mechanism of supervised machine learning. Taken from Logpoint page.

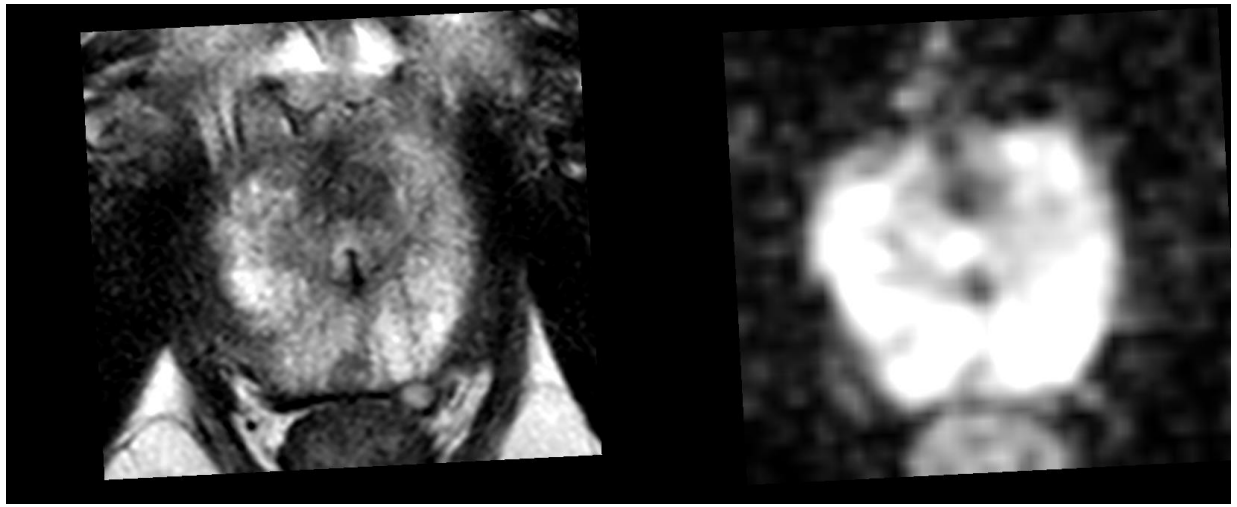
AUC: metric to measure performance



Different ROC curves their respective AUC score. Image from Data Analysis (Edited).

Our Information

T2w



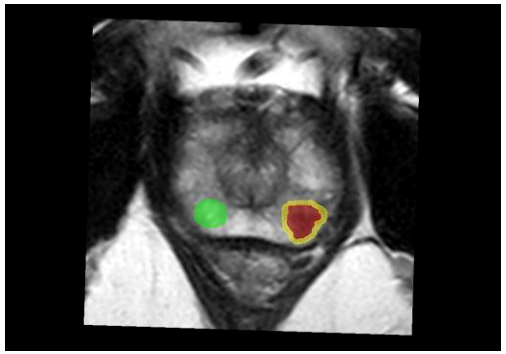
ADC

Table 1. Patient Characteristics	
Total number of patients with PCA included	86
Age (years), mean ± SD	60 ± 8.2
Comorbidities N (%)	63 (73)
Arterial hypertension	38 (44)
DM	19 (22)
Tabacco	13 (15)
PSA (ng/mL), median (IQR)	8.6 (10.8 - 4.7)
Prostate volume (mL, median (IQR)	48 (58 - 33)
PSA-D MR	0.22 (0.3 - 0.1)
PI-RADS N (%)	
3	2 (2)
4	60 (70)
5	24 (28)
Gleason Score N (%)	
6	20 (23)
7 (3 + 4)	28 (33)
7 (4 + 3)	21 (24)
8	5 (6)
9	12 (14)

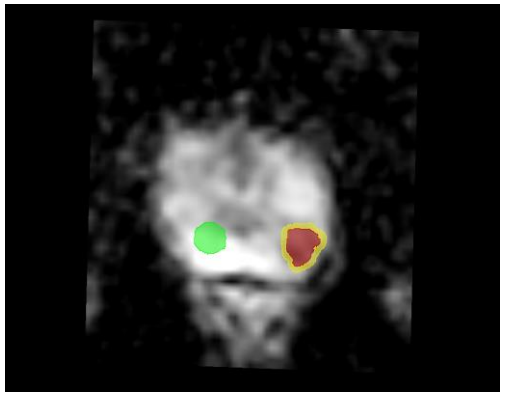
SD = standard deviation; PSA = prostate-specific antigen; IQR = interquartile range; DM = diabetes mellitus

PCa = prostate carcinoma; PSA-D RM = prostate-specific antigen density by magnetic resonance.

ROI segmentation



T2w image series

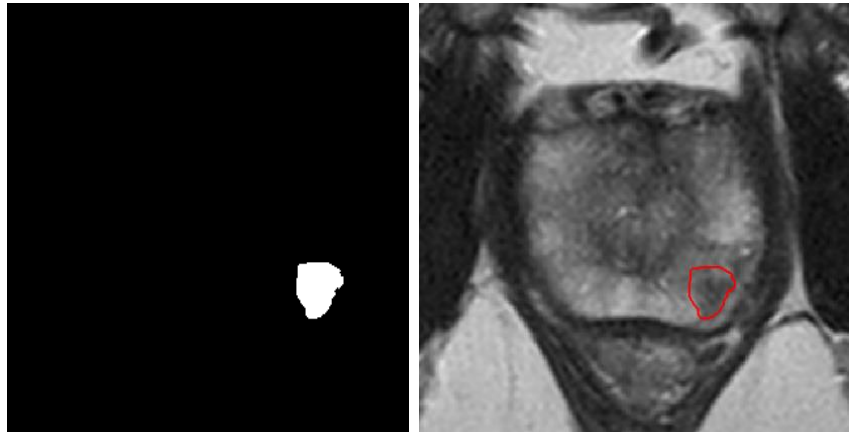


ADC image series

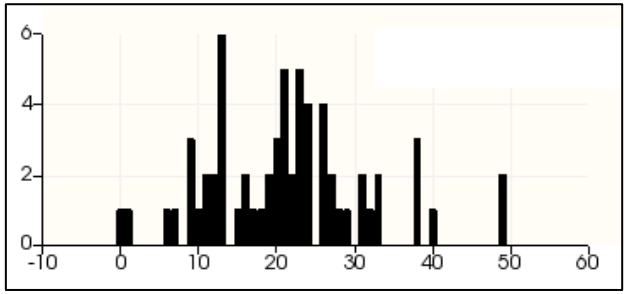
Red region corresponds to the nodule and the green region to the benign zone.

Feature extraction (from 3D to 2D)

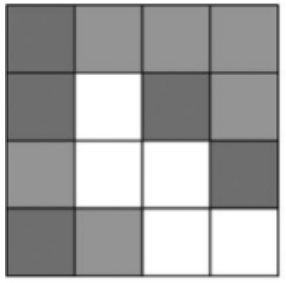
Images were exported from **3D Slicer** in .nrrd (MRI) and .nii (mask). Which contain all the slices. Using **Python** the slices with a segmentation were identified.



Statistical features (First Order)



Textural features



Shape features

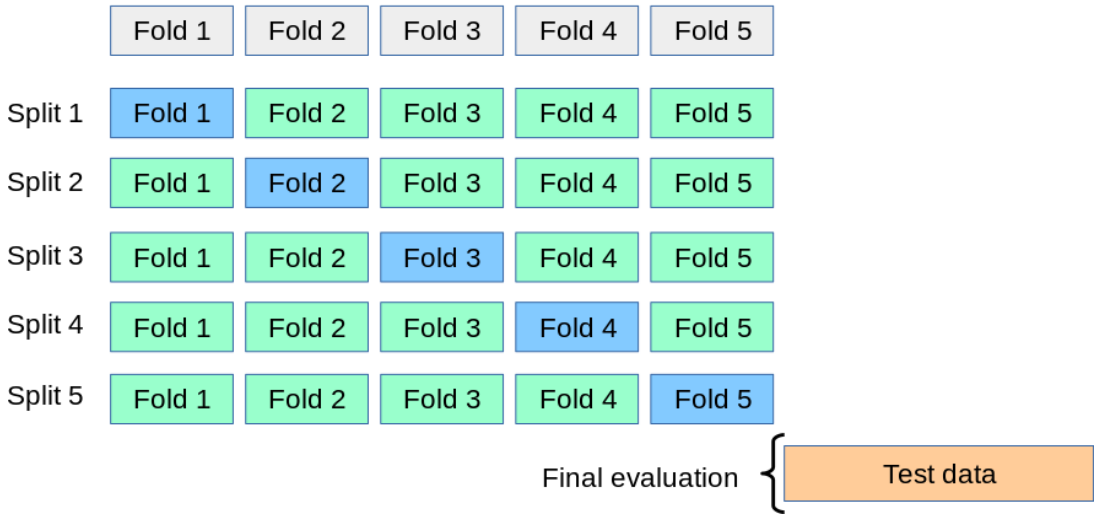
Clinical features

Using Pyradiomics 97 features were extracted

Split Train/Test Data

Training data | Test data

Cross Validation (Stratified K-fold)



Validation/Test Models
(Final Evaluation)

Feature selection

- Univariate analysis
  - Statistical analysis
  - Correlation analysis
  - AUC Scores and ROC Curves
  - Bootstrap

Manual selection

- From statistical meaningful features and features with AUC upper 0.7 (no correlated)

Automatic selection

- Feature selection algorithms

Supervised machine learning model

Radiomic Quality Score (RQS)

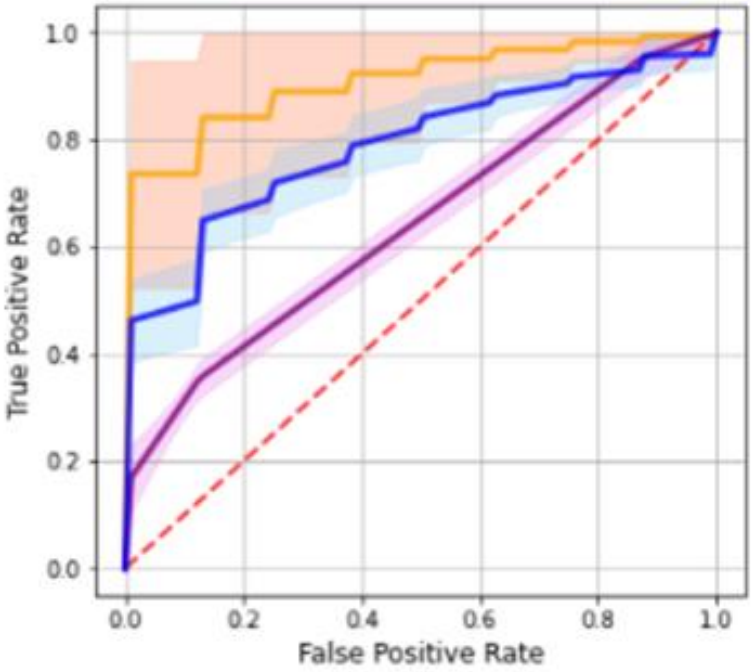
- Based on Stanzione et al. (2020)

Results

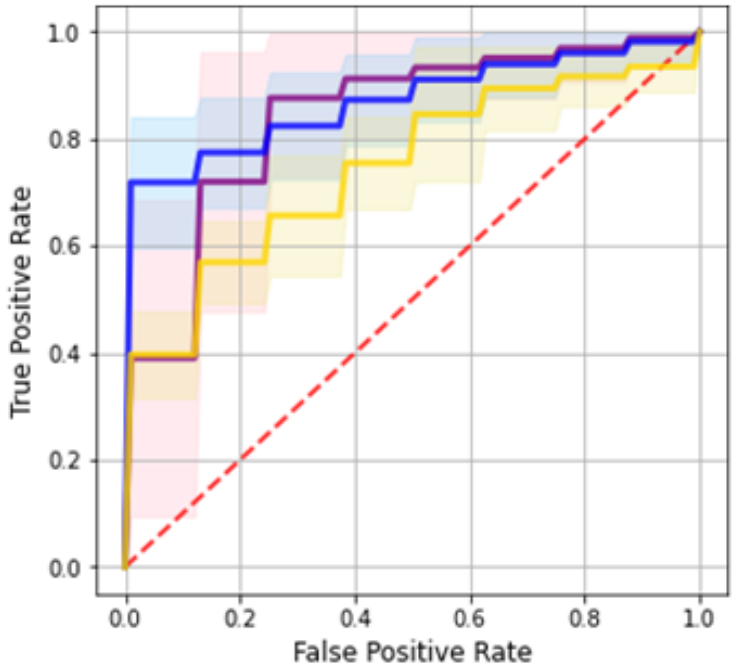
Data Set	N°	Best Classifier	$\bar{x}_{AUC}$ (σ_{AUC}) C.I
GS= 6 vs GS ≥ 7			
T2w	4	LR	0.85 (0.06) [0.71 – 0.95]
ADC	6	LR	0.82 (0.09) [0.57 – 0.94]
T2w + ADC	6	LR	0.87 (0.05) [0.77 – 0.95]
GS ≤ 3 + 4 vs GS ≥ 4 + 3			
T2w	4	LR	0.80 (0.06) [0.65 – 0.91]
ADC	2	SVM	0.89 (0.01) [0.86 – 0.91]
T2w + ADC	4	LR	0.87 (0.05) [0.75 – 0.96]

ROC Curves

GS≥7 vs GS = 6

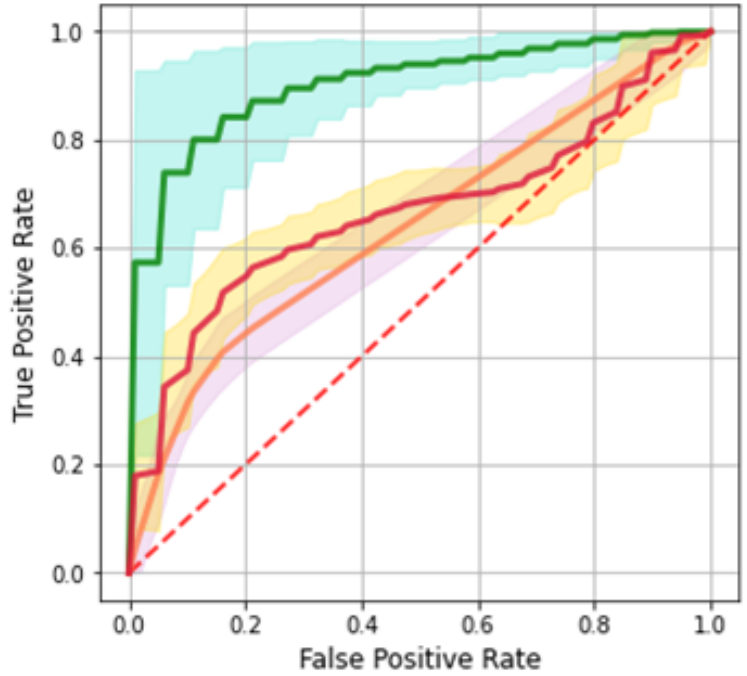


Chance
Mean ROC Model 1 (AUC = 0.91 (0.06))
Mean ROC PIRADS-v2 (AUC = 0.64 (0.05))
Mean ROC PSA Density (AUC = 0.79 (0.06))
± 2 std. dev. (C.I 95%) Model 1
± 2 std. dev. (C.I 95%) PIRADS-v2
± 2 std. dev. (C.I 95%) PSA Density



Chance
Mean ROC Clinical Info. (AUC = 0.84 (0.07))
Mean ROC Texture Info. (AUC = 0.87 (0.05))
Mean ROC Univariate (AUC = 0.74 (0.07))
± 2 std. dev. (C.I 95%) Clinical Info.
± 2 std. dev. (C.I 95%) Texture Info.
± 2 std. dev. (C.I 95%) Univariate

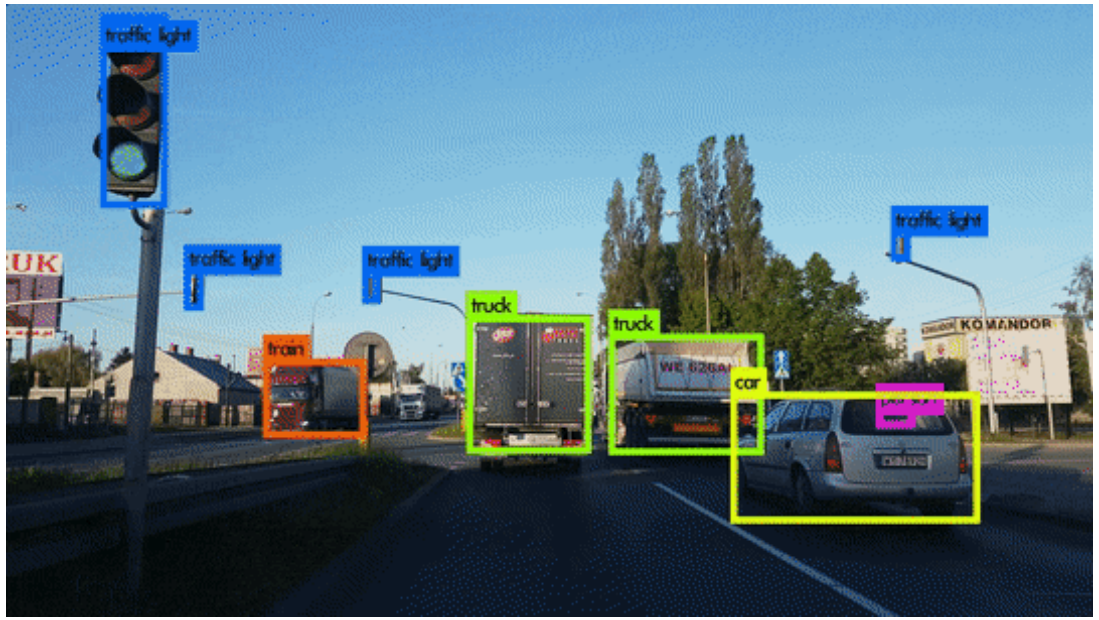
GS≥4+3 vs GS ≤ 3+4

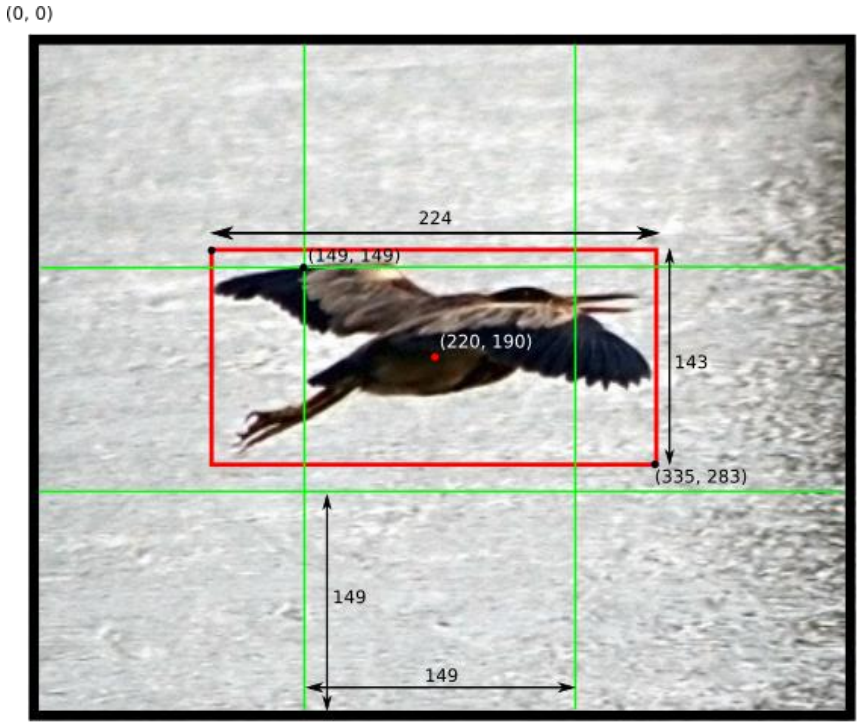


Chance
Mean ROC Model 2 (AUC = 0.90 (0.05))
Mean ROC PIRADS-v2 (AUC = 0.64 (0.06))
Mean ROC PSA Density (AUC = 0.67 (0.07))
± 2 std. dev. (C.I 95%) Model 2
± 2 std. dev. (C.I 95%) PIRADS-v2
± 2 std. dev. (C.I 95%) PSA Density

2. Detection and automatic segmentation of intraprostatic Lesions using Deep Learning Tools

Object Detection (BBoxes for Yolo)



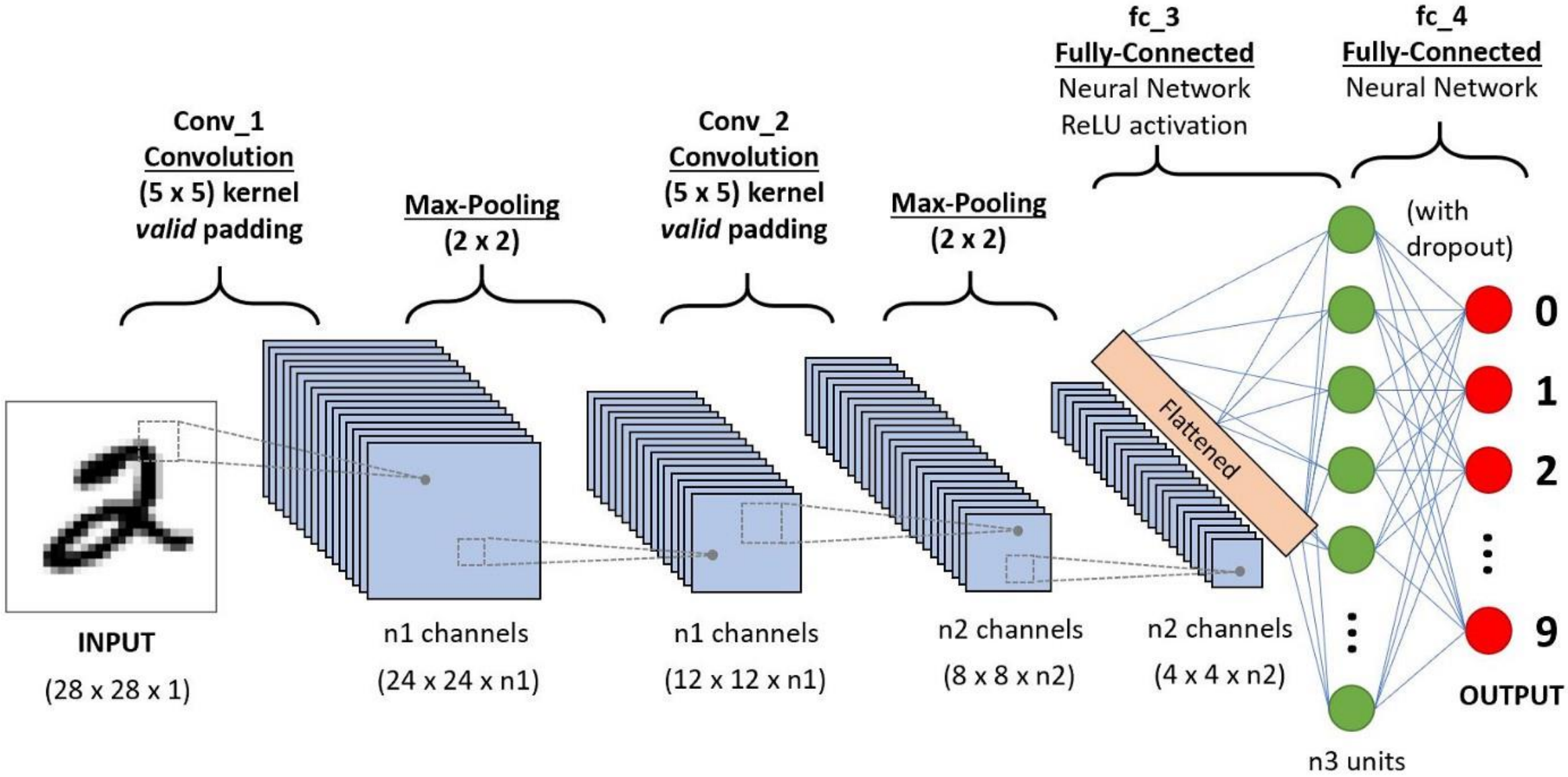


x = (220-149) / 149 = 0.48

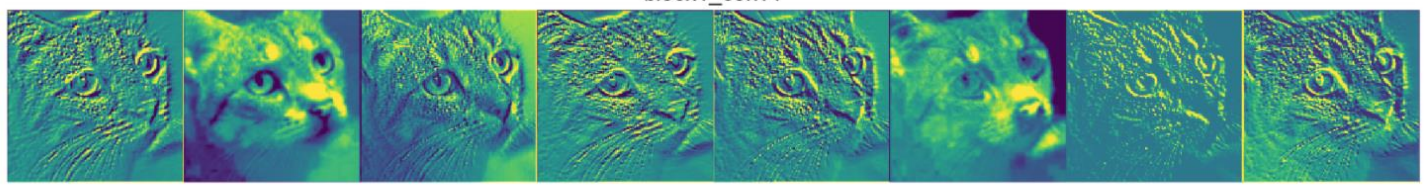
y = (190-149) / 149 = 0.28

w = 224 / 448 = 0.50

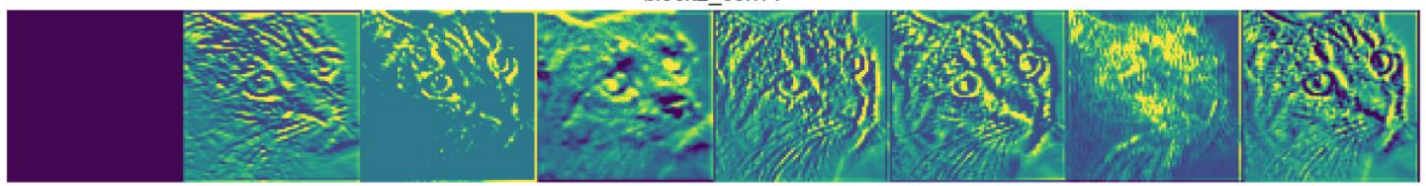
h = 143 / 448 = 0.32


Conv_1
Convolution
(5 x 5) kernel
valid padding
Max-Pooling
(2 x 2)
Conv_2
Convolution
(5 x 5) kernel
valid padding
Max-Pooling
(2 x 2)
fc_3
Fully-Connected
Neural Network
ReLU activation
fc_4
Fully-Connected
Neural Network
(with dropout)
Flattened
INPUT
(28 x 28 x 1)
n1 channels
(24 x 24 x n1)
n1 channels
(12 x 12 x n1)
n2 channels
(8 x 8 x n2)
n2 channels
(4 x 4 x n2)
n3 units
0
1
2
9
OUTPUT

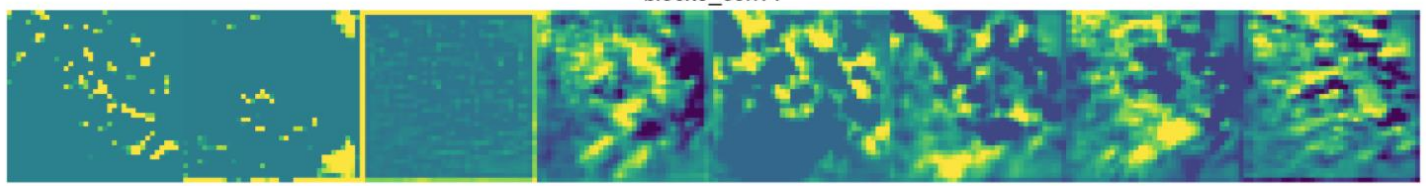
block1_conv1



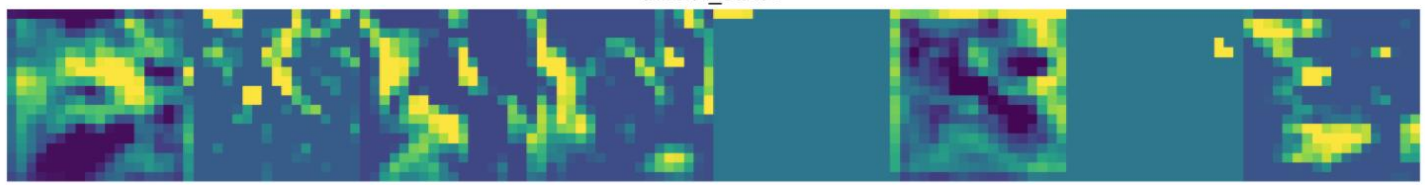
block2_conv1



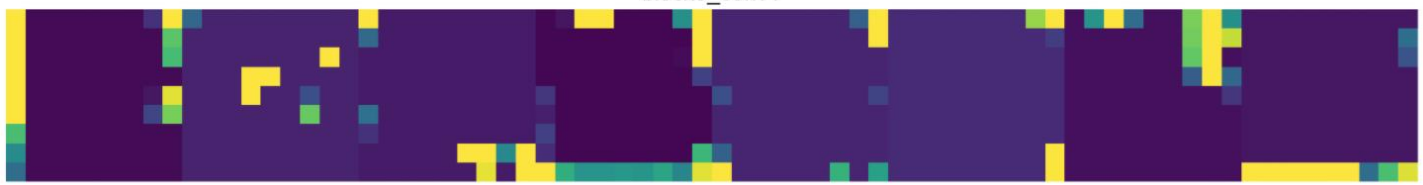
block3_conv1



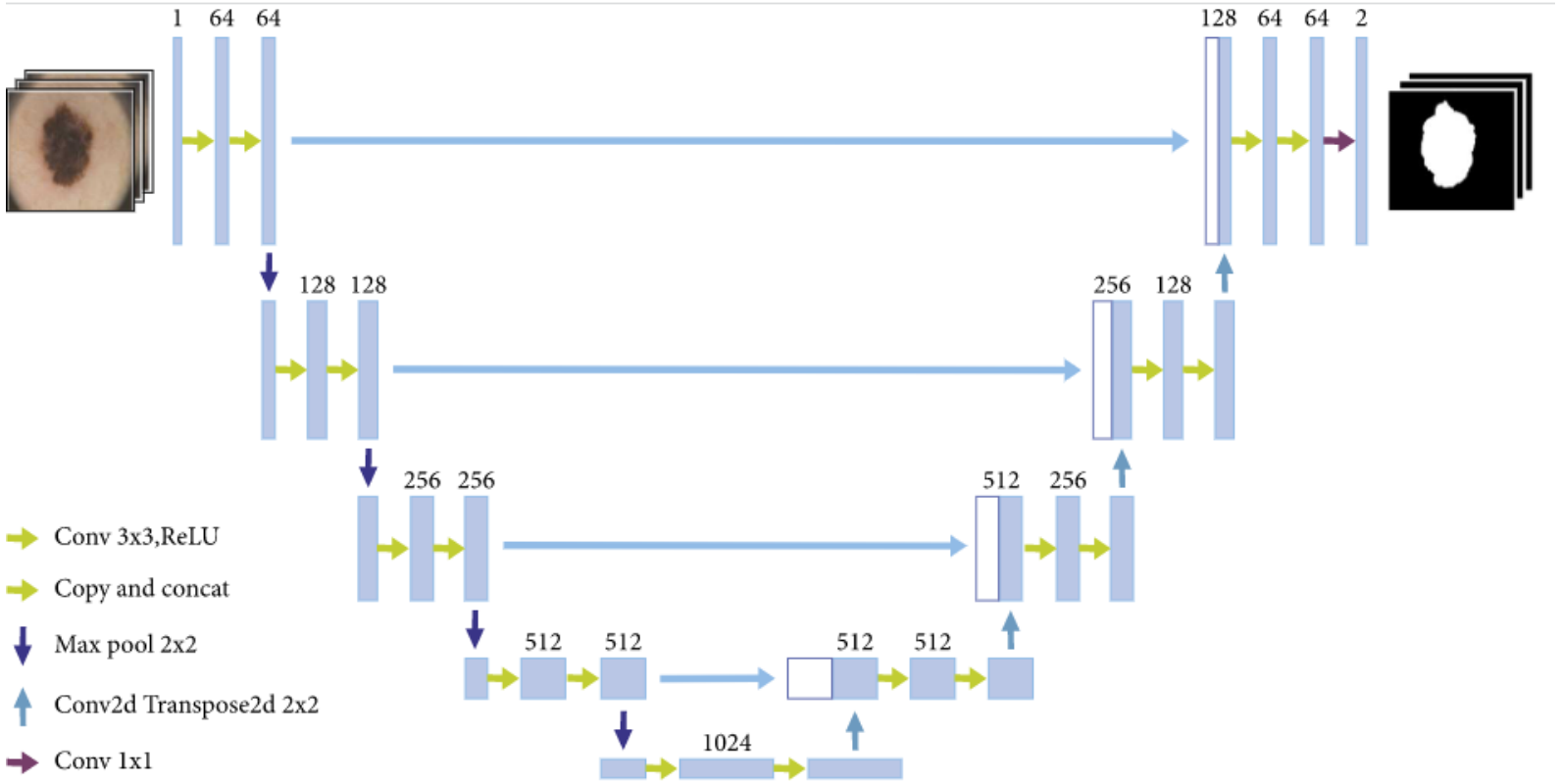
block4_conv1



block5_conv1



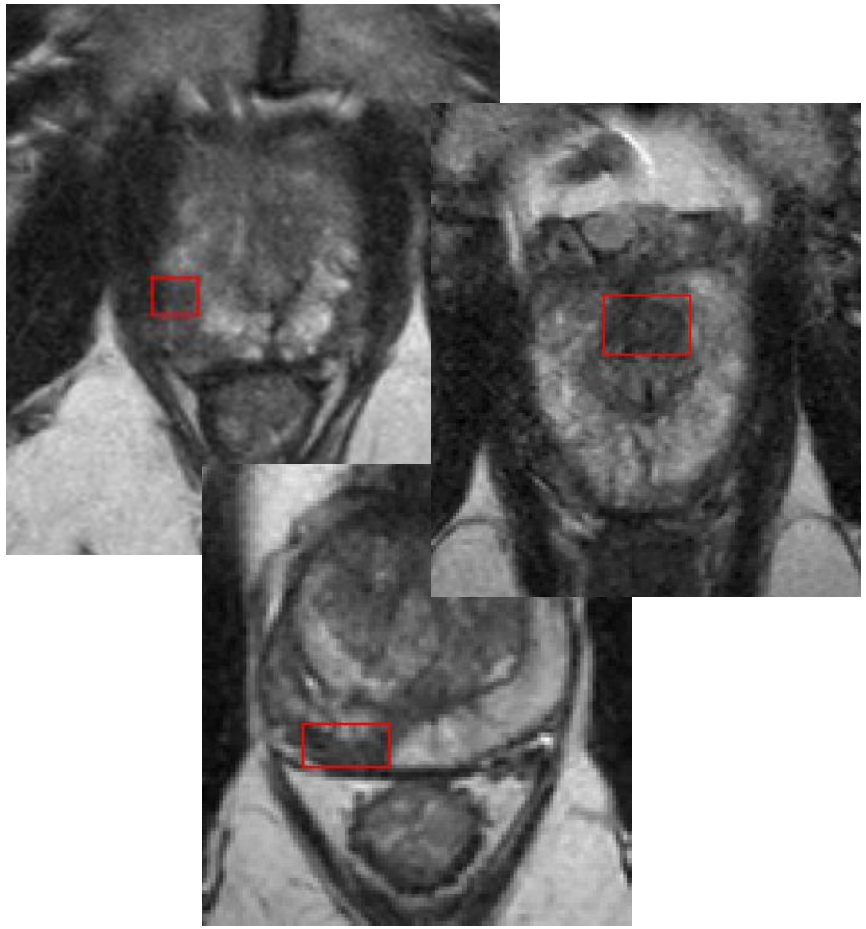
U- net

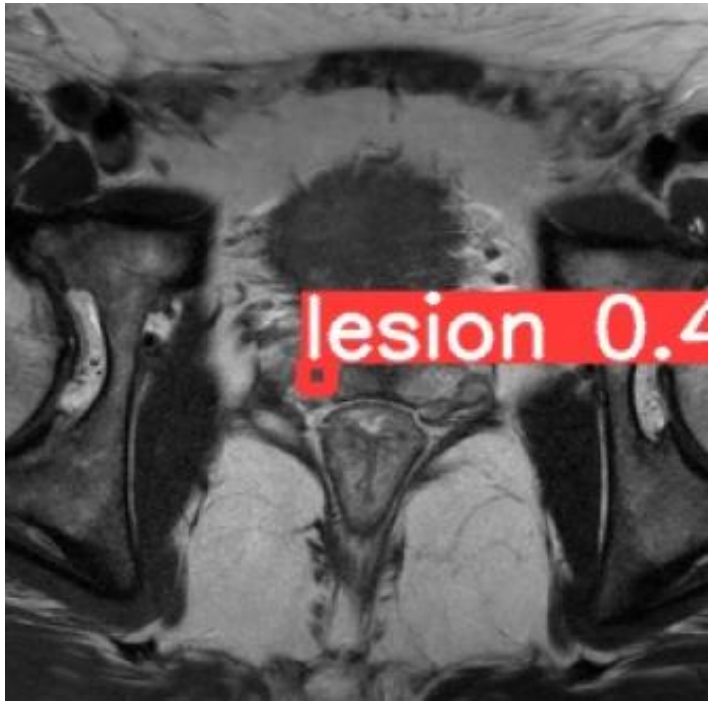


3_0	3_1	2_2	1	0
0_2	0_2	1_0	3	1
3_0	1_1	2_2	2	3
2	0	0	2	2
2	0	0	0	1

12.0	12.0	17.0
10.0	17.0	19.0
9.0	6.0	14.0

First Results





Discussion and future work

- **There are several limitations in both projects** that can be improved and that can be part of a future work, as the needing of an **external cohort to validate the work** that were carried out, and increase the amount of patients.

- Evaluate and improve robustness of the best models, to replicate results in the future.

- We demonstrate the using of ML and DL could predict the risk group of Pca, and identify intraprostatic lesions, that could improve the application of different treatments, like radiotherapy.