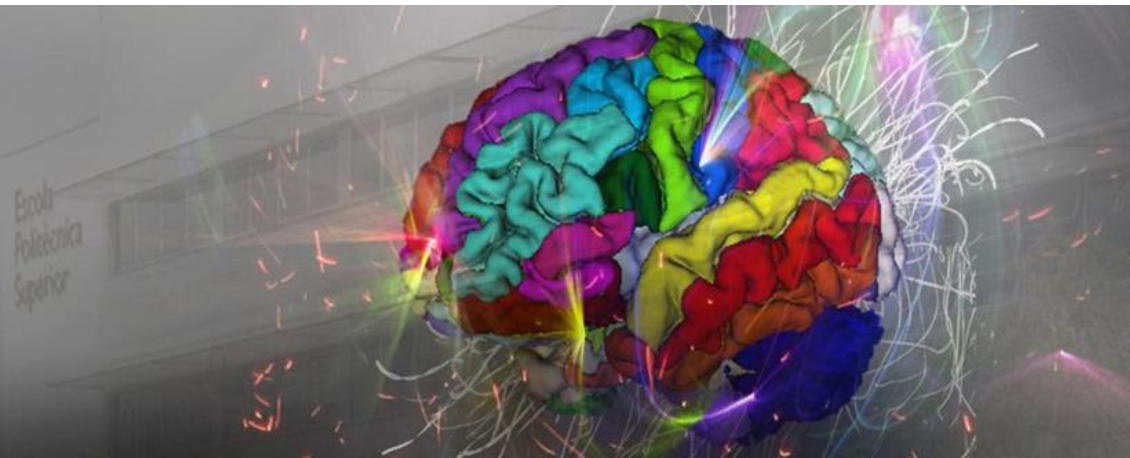




CAD Project: Classical Approach

Jaime Simarro, Ahmed Gouda



Methodology

- Preprocessing

- Color Space Transformation

- Feature Extraction

- Machine Learning

Experiments

- Based on Cross Validation

 - Feature selection

 - Grid research of Candidate models

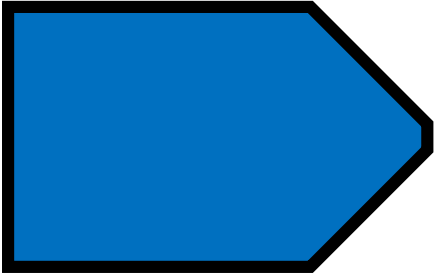
- Based on validation

 - Candidate model selection

Final Results

- Ensemble and ROC curves

Methodology

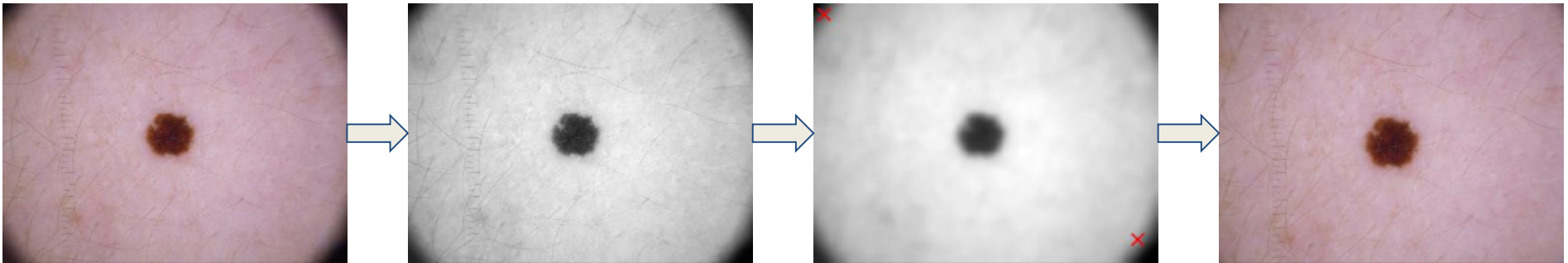


Preprocessing

Methodology: Preprocessing

Dermo

- Removing dark corner artefact



RGB to Gray

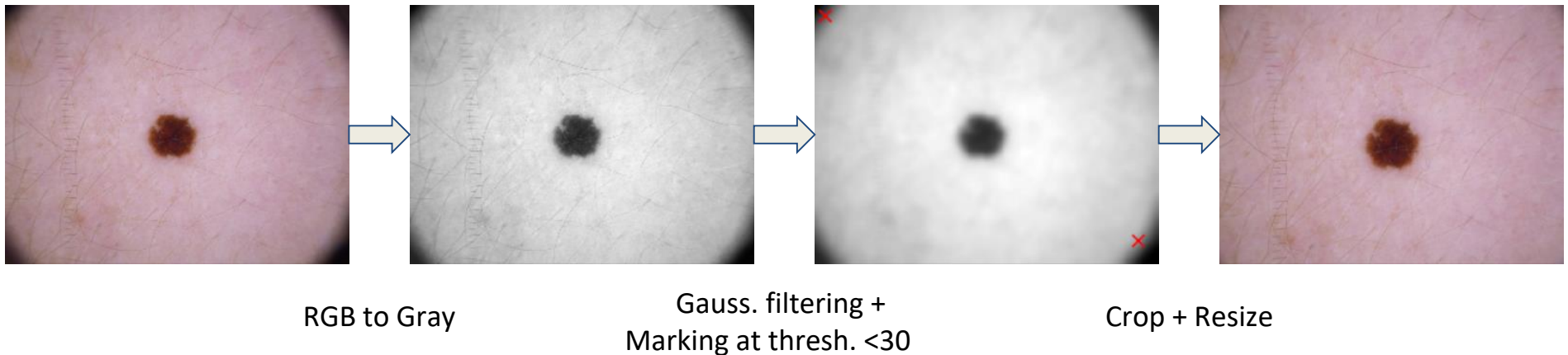
Gauss. filtering +
Marking at thresh. <30

Crop + Resize

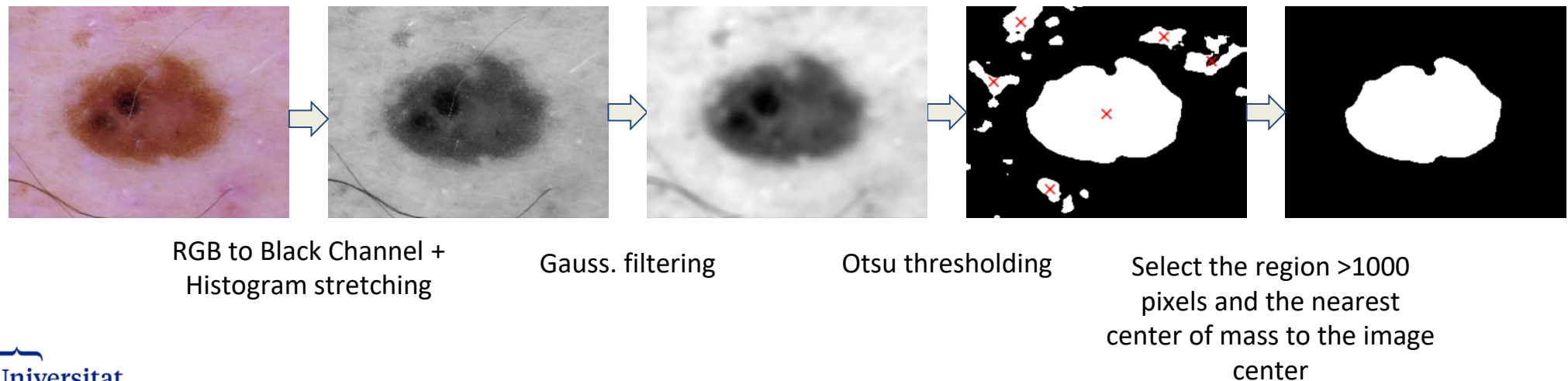
Methodology: Preprocessing

Dermo

- Removing dark corner artefact



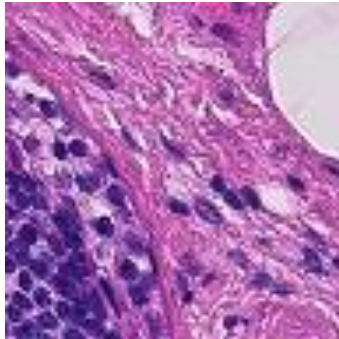
- Segmentation



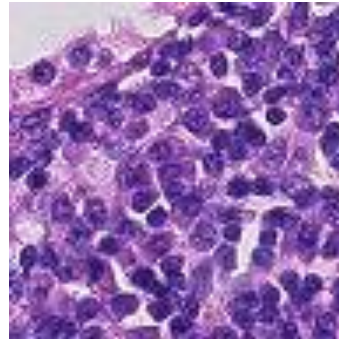
Methodology: Preprocessing

Histopathology:

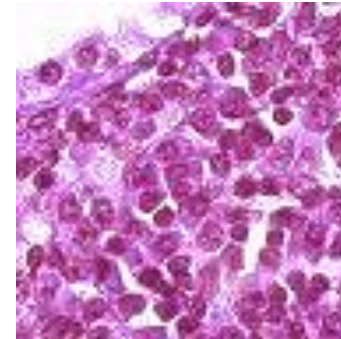
- Color Normalization



Reference image



Original image

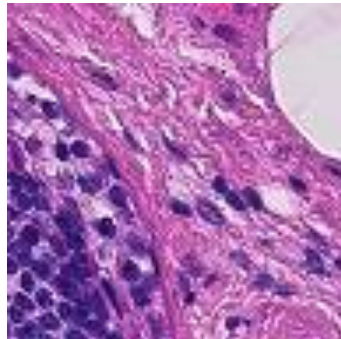


Color normalized
image using Reinhard

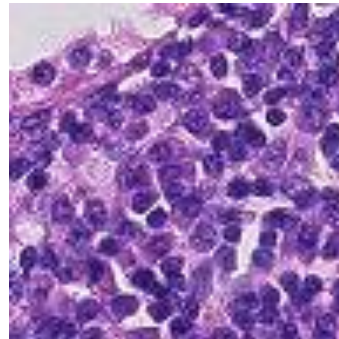
Methodology: Preprocessing

Histopathology:

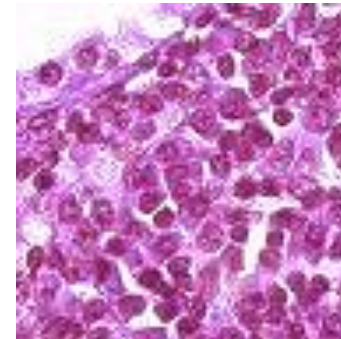
- Color Normalization



Reference image

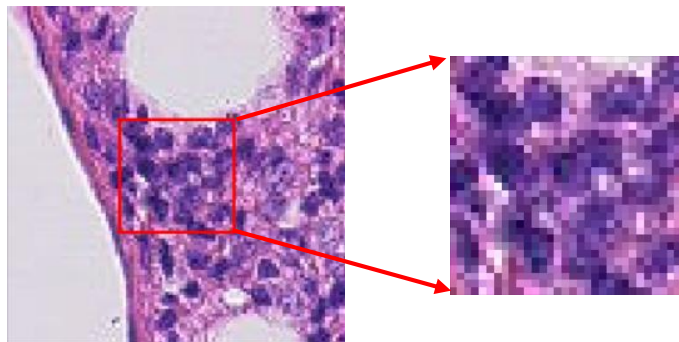


Original image

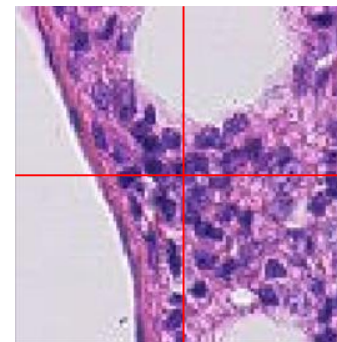


Color normalized
image using Reinhard

- Windowing

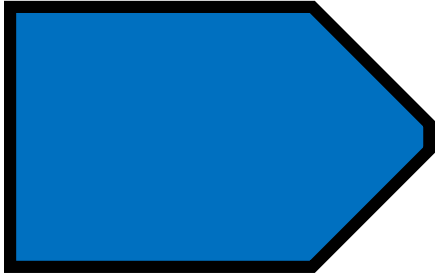


Middle window (32×32 pixels)

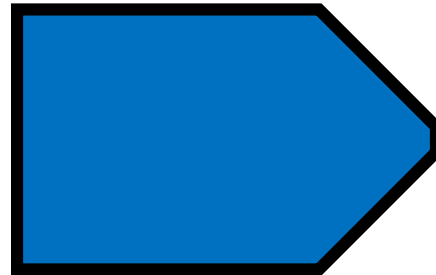


Dividing into 4 regions

Methodology



Preprocessing



Color Space
Transformation

Methodology: Color Spaces

Common Color Spaces:

- RGB
- CIE L*a*b*
- HSV
- JCH

Methodology: Color Spaces

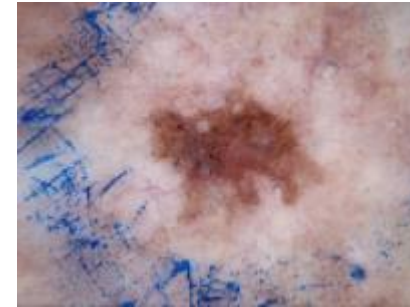
Common Color Spaces:

- RGB
- CIE L*a*b*
- HSV
- JCH

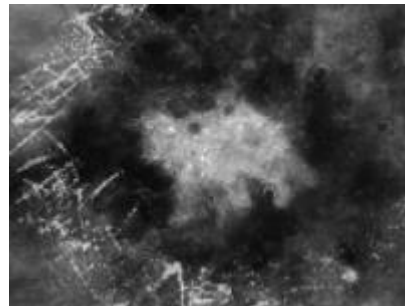
Dermo Specified:

- Six Melanoma Colors [1]

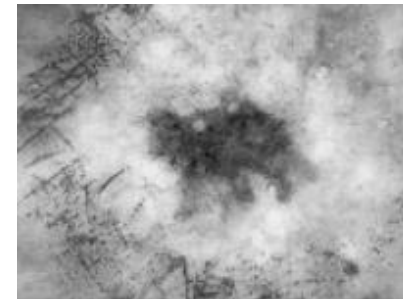
Original image



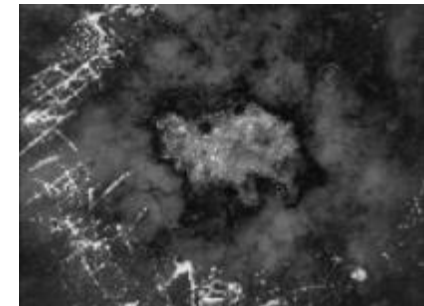
White



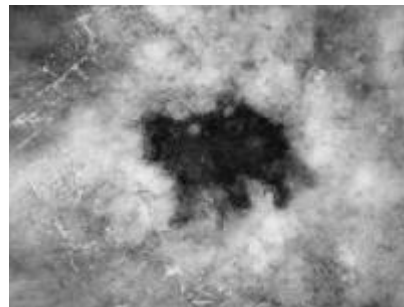
Black



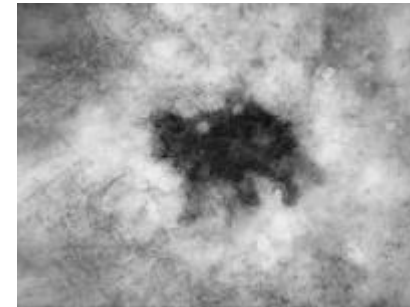
Red



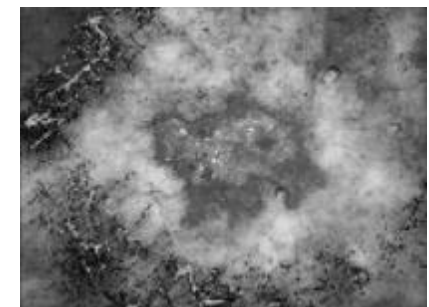
Light-brown



Dark-brown



Blue-gray



Methodology: Color Spaces

Common Color Spaces:

- RGB
- CIE L*a*b*
- HSV
- JCH

$$S = PC1 = 0.088 \frac{G}{R + G + B} - 58.89G - 30.014R - 11.952B - 7.24$$

Dermo Specified:

- Six Melanoma Colors [1]
- Hybrid Colors Spaces [2]

$$K = PC2 = 2.122 B + 14.859 G + 6.921R + 0.62 \frac{G}{R + G + B} + 1.744$$

$$N = PC3 = 0.342 \frac{G}{R + G + B} - 3.698G - 2.25R - 0.103B - 0.464$$

Methodology: Color Spaces

Common Color Spaces:

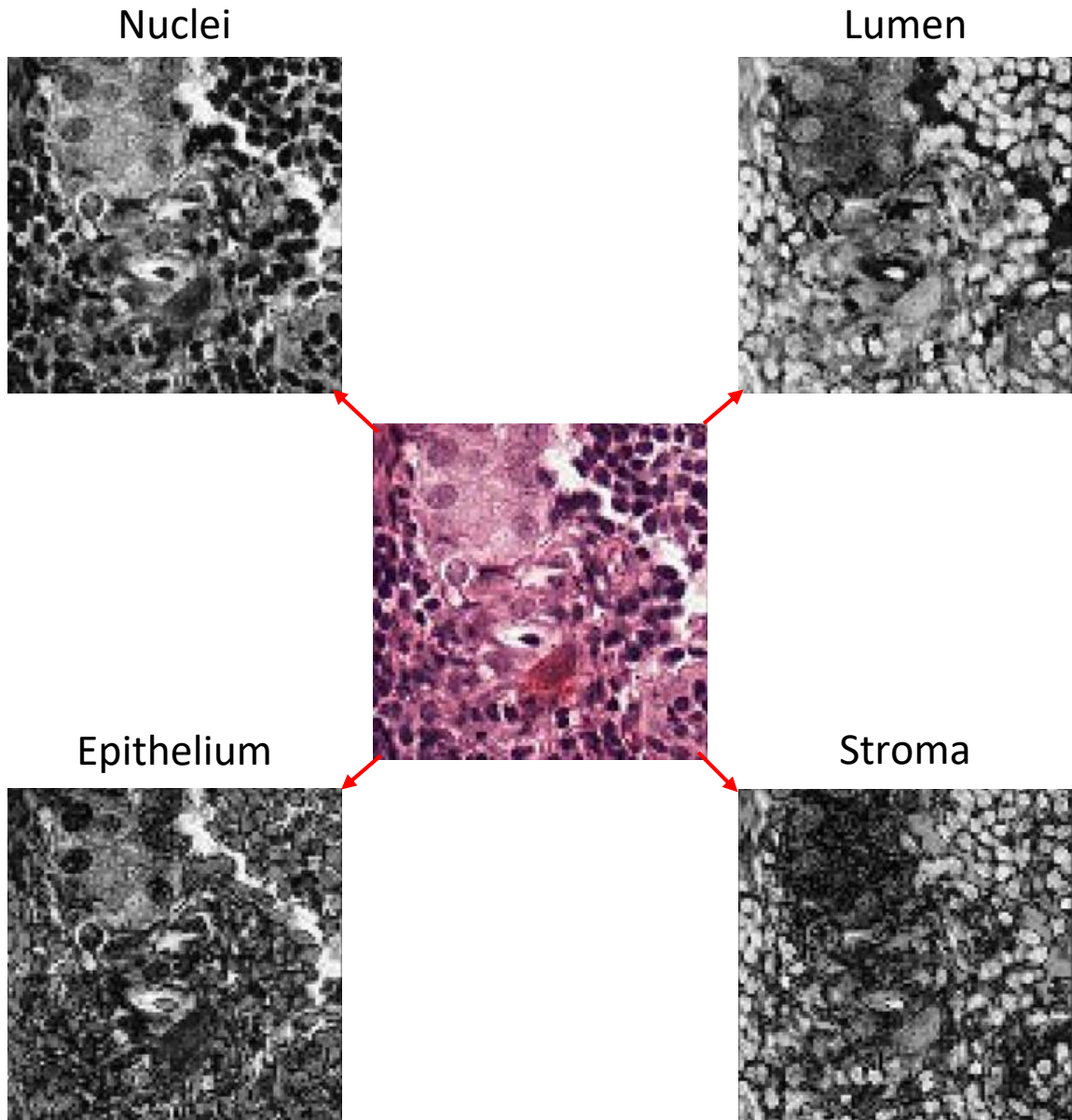
- RGB
- CIE L*a*b*
- HSV
- JCH

Dermo Specified:

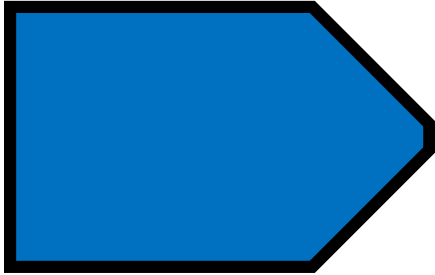
- Six Melanoma Colors [1]
- Hybrid Colors Spaces [2]

Histopathology Specified:

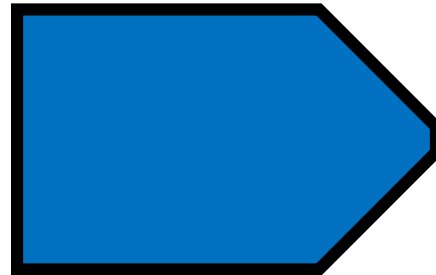
- 4 tissue classes [3]



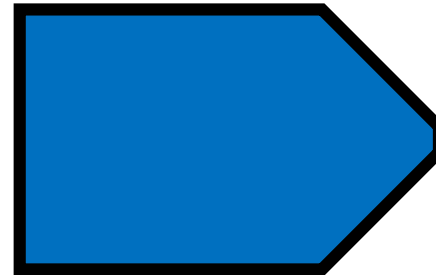
Methodology



Preprocessing



Color Space
Transformation



Feature
Extraction

Histogram:

- 10 bins histogram

Intensity:

- Mean
- Skewness
- kurtosis

Statistical:

- Smoothness
- Uniformity
- Entropy

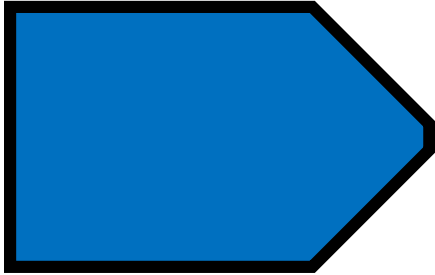
GLCM:

- Dissimilarity
- Correlation
- Contrast
- Homogeneity
- ASM
- Energy

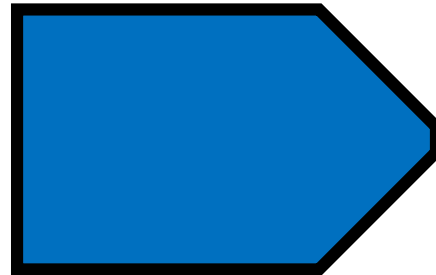
Gabor:

- 16 Gabor kernels

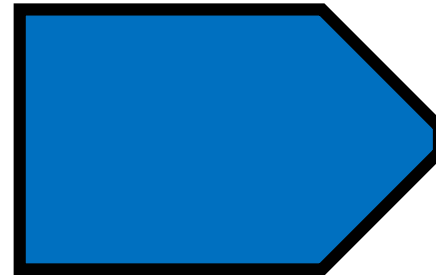
Methodology



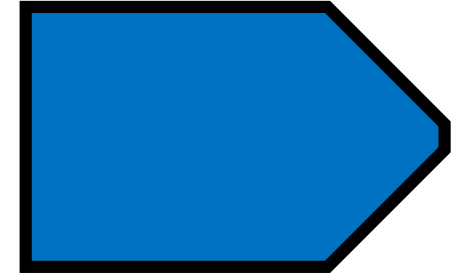
Preprocessing



Color Space
Transformation



Feature
Extraction



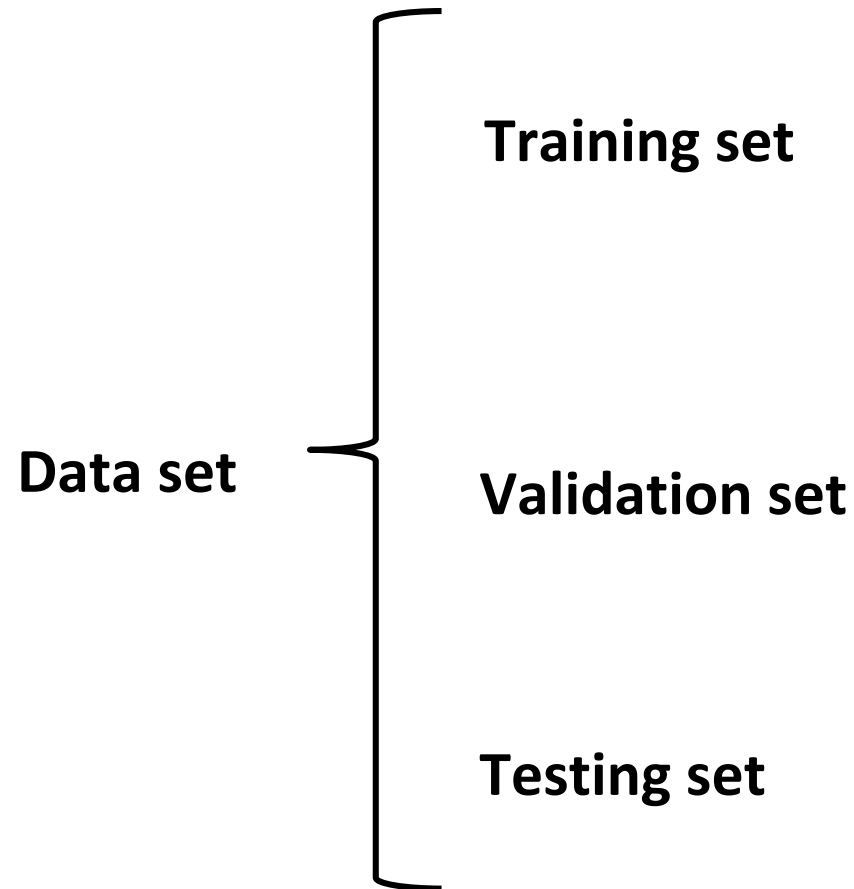
**Machine
Learning**

Methodology: Machine Learning

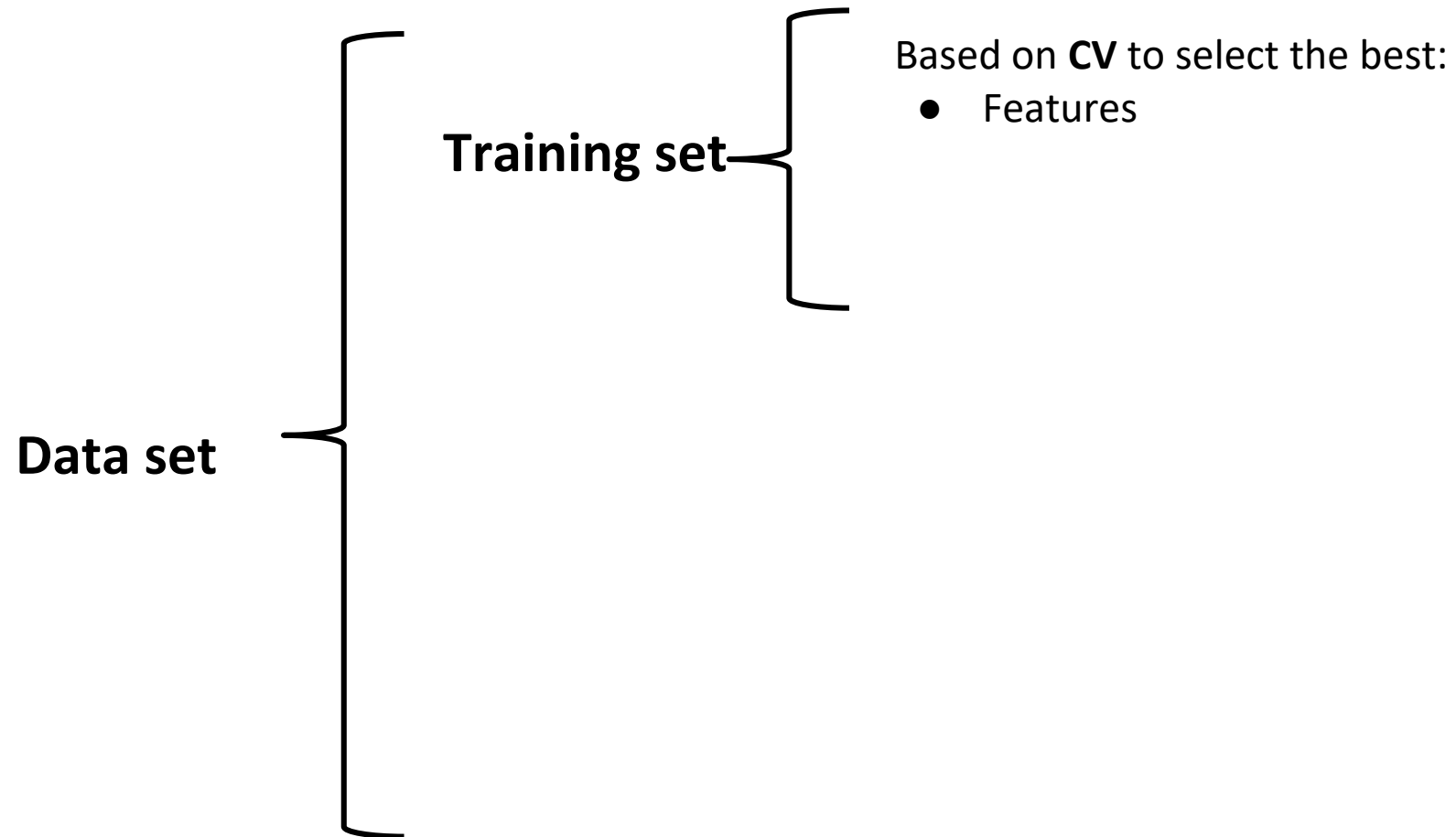
Normalization	Feature selection	Models
<ul style="list-style-type: none">• L2 (The sum of squared value is equal to 1)• mean=0 & std=1	<ul style="list-style-type: none">• mRMR• F-Value	<ul style="list-style-type: none">• SVM• Random Forest

Experiments

Experiments



Experiments



Histopathology: Original

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	79.6 +/- 0.86	80.52 +/- 0.82	79.97 +/- 1.3	80.39 +/- 0.65	80.45 +/- 1.0	84.18 +/- 0.77
Histogram	83.43 +/- 1.06	83.86 +/- 1.08	82.83 +/- 1.04	83.23 +/- 0.91	80.78 +/- 1.14	85.36 +/- 1.04
Fintesity	77.61 +/- 1.31	77.38 +/- 1.23	76.97 +/- 1.61	77.08 +/- 1.12	77.31 +/- 0.95	81.26 +/- 0.79
Fstat	79.04 +/- 1.1	78.88 +/- 0.7	79.9 +/- 0.8	78.97 +/- 1.01	78.3 +/- 0.79	83.34 +/- 1.06
Gabor	83.73 +/- 0.91	84.12 +/- 0.68	84.48 +/- 1.0	83.47 +/- 0.95	82.5 +/- 1.1	86.76 +/- 0.69
Combination of features	85.31 +/- 0.88	86.45 +/- 0.4	86.94 +/- 1.15	86.6 +/- 0.92	83.06 +/- 1.23	87.45 +/- 0.63

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	84.21 +/- 0.93	84.72 +/- 0.86	84.73 +/- 1.07	84.71 +/- 0.96	83.14 +/- 1.12	86.95 +/- 0.89
Histogram	86.57 +/- 1.16	87.4 +/- 0.84	85.52 +/- 1.15	86.28 +/- 0.98	84.36 +/- 1.47	87.72 +/- 1.23
Fintesity	85.25 +/- 0.7	85.65 +/- 0.45	86.3 +/- 0.58	85.33 +/- 1.13	81.91 +/- 1.46	87.28 +/- 1.0
Fstat	83.88 +/- 1.04	83.96 +/- 0.82	83.94 +/- 1.14	83.78 +/- 0.74	81.26 +/- 1.44	86.7 +/- 1.16
Gabor	86.41 +/- 1.27	87.44 +/- 0.94	88.28 +/- 1.15	87.16 +/- 0.93	84.72 +/- 0.92	88.69 +/- 1.04
Combination of features	88.06 +/- 1.25	88.89 +/- 1.02	89.12 +/- 1.02	89.06 +/- 0.97	85.7 +/- 1.32	89.46 +/- 0.89

Histopathology: Original

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	79.6 +/- 0.86	80.52 +/- 0.82	79.97 +/- 1.3	80.39 +/- 0.65	80.45 +/- 1.0	84.18 +/- 0.77
Histogram	83.43 +/- 1.06	83.86 +/- 1.08	82.83 +/- 1.04	83.23 +/- 0.91	80.78 +/- 1.14	85.36 +/- 1.04
Fintesity	77.61 +/- 1.31	77.38 +/- 1.23	76.97 +/- 1.61	77.08 +/- 1.12	77.31 +/- 0.95	81.26 +/- 0.79
Fstat	79.04 +/- 1.1	78.88 +/- 0.7	79.9 +/- 0.8	78.97 +/- 1.01	78.3 +/- 0.79	83.34 +/- 1.06
Gabor	83.73 +/- 0.91	84.12 +/- 0.68	84.48 +/- 1.0	83.47 +/- 0.95	82.5 +/- 1.1	86.76 +/- 0.69
Combination of features	85.31 +/- 0.88	86.45 +/- 0.4	86.94 +/- 1.15	86.6 +/- 0.92	83.06 +/- 1.23	87.45 +/- 0.63

Global+Window

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	84.21 +/- 0.93	84.72 +/- 0.86	84.73 +/- 1.07	84.71 +/- 0.96	83.14 +/- 1.12	86.95 +/- 0.89
Histogram	86.57 +/- 1.16	87.4 +/- 0.84	85.52 +/- 1.15	86.28 +/- 0.98	84.36 +/- 1.47	87.72 +/- 1.23
Fintesity	85.25 +/- 0.7	85.65 +/- 0.45	86.3 +/- 0.58	85.33 +/- 1.13	81.91 +/- 1.46	87.28 +/- 1.0
Fstat	83.88 +/- 1.04	83.96 +/- 0.82	83.94 +/- 1.14	83.78 +/- 0.74	81.26 +/- 1.44	86.7 +/- 1.16
Gabor	86.41 +/- 1.27	87.44 +/- 0.94	88.28 +/- 1.15	87.16 +/- 0.93	84.72 +/- 0.92	88.69 +/- 1.04
Combination of features	88.06 +/- 1.25	88.89 +/- 1.02	89.12 +/- 1.02	89.06 +/- 0.97	85.7 +/- 1.32	89.46 +/- 0.89

Histopathology: Original

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	79.6 +/- 0.86	80.52 +/- 0.82	79.97 +/- 1.3	80.39 +/- 0.65	80.45 +/- 1.0	84.18 +/- 0.77
Histogram	83.43 +/- 1.06	83.86 +/- 1.08	82.83 +/- 1.04	83.23 +/- 0.91	80.78 +/- 1.14	85.36 +/- 1.04
Fintesity	77.61 +/- 1.31	77.38 +/- 1.23	76.97 +/- 1.61	77.08 +/- 1.12	77.31 +/- 0.95	81.26 +/- 0.79
Fstat	79.04 +/- 1.1	78.88 +/- 0.7	79.9 +/- 0.8	78.97 +/- 1.01	78.3 +/- 0.79	83.34 +/- 1.06
Gabor	83.73 +/- 0.91	84.12 +/- 0.68	84.48 +/- 1.0	83.47 +/- 0.95	82.5 +/- 1.1	86.76 +/- 0.69
Combination of features	85.31 +/- 0.88	86.45 +/- 0.4	86.94 +/- 1.15	86.6 +/- 0.92	83.06 +/- 1.23	87.45 +/- 0.63

Global+Window

Global

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	84.21 +/- 0.93	84.72 +/- 0.86	84.73 +/- 1.07	84.71 +/- 0.96	83.14 +/- 1.12	86.95 +/- 0.89
Histogram	86.57 +/- 1.16	87.4 +/- 0.84	85.52 +/- 1.15	86.28 +/- 0.98	84.36 +/- 1.47	87.72 +/- 1.23
Fintesity	85.25 +/- 0.7	85.65 +/- 0.45	86.3 +/- 0.58	85.33 +/- 1.13	81.91 +/- 1.46	87.28 +/- 1.0
Fstat	83.88 +/- 1.04	83.96 +/- 0.82	83.94 +/- 1.14	83.78 +/- 0.74	81.26 +/- 1.44	86.7 +/- 1.16
Gabor	86.41 +/- 1.27	87.44 +/- 0.94	88.28 +/- 1.15	87.16 +/- 0.93	84.72 +/- 0.92	88.69 +/- 1.04
Combination of features	88.06 +/- 1.25	88.89 +/- 1.02	89.12 +/- 1.02	89.06 +/- 0.97	85.7 +/- 1.32	89.46 +/- 0.89

Histopathology: Original

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	79.6 +/- 0.86	80.52 +/- 0.82	79.97 +/- 1.3	80.39 +/- 0.65	80.45 +/- 1.0	84.18 +/- 0.77
Histogram	83.43 +/- 1.06	83.86 +/- 1.08	82.83 +/- 1.04	83.23 +/- 0.91	80.78 +/- 1.14	85.36 +/- 1.04
Fintesity	77.61 +/- 1.31	77.38 +/- 1.23	76.97 +/- 1.61	77.08 +/- 1.12	77.31 +/- 0.95	81.26 +/- 0.79
Fstat	79.04 +/- 1.1	78.88 +/- 0.7	79.9 +/- 0.8	Less std means more robust		83.34 +/- 1.06
Gabor	83.73 +/- 0.91	84.12 +/- 0.68	84.48 +/- 1.0			86.76 +/- 0.69
Combination of features	85.31 +/- 0.88	86.45 +/- 0.4	86.94 +/- 1.15	86.6 +/- 0.92	83.06 +/- 1.23	87.45 +/- 0.63

Global+Window

Global

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	84.21 +/- 0.93	84.72 +/- 0.86	84.73 +/- 1.07	84.71 +/- 0.96	83.14 +/- 1.12	86.95 +/- 0.89
Histogram	86.57 +/- 1.16	87.4 +/- 0.84	85.52 +/- 1.15	86.28 +/- 0.98	84.36 +/- 1.47	87.72 +/- 1.23
Fintesity	85.25 +/- 0.7	85.65 +/- 0.45	86.3 +/- 0.58	85.33 +/- 1.13	81.91 +/- 1.46	87.28 +/- 1.0
Fstat	83.88 +/- 1.04	83.96 +/- 0.82	83.94 +/- 1.14	83.78 +/- 0.74	81.26 +/- 1.44	86.7 +/- 1.16
Gabor	86.41 +/- 1.27	87.44 +/- 0.94	88.28 +/- 1.15	87.16 +/- 0.93	84.72 +/- 0.92	88.69 +/- 1.04
Combination of features	88.06 +/- 1.25	88.89 +/- 1.02	89.12 +/- 1.02	89.06 +/- 0.97	85.7 +/- 1.32	89.46 +/- 0.89

Histopathology: Reinard

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	77.97 +/- 0.68	77.9 +/- 1.09	75.65 +/- 1.22	77.17 +/- 1.3	78.61 +/- 0.81	81.94 +/- 0.87
Histogram	83.07 +/- 0.78	81.54 +/- 0.82	81.73 +/- 0.62	81.71 +/- 0.6	80.86 +/- 0.74	84.89 +/- 0.94
Fintesity	78.99 +/- 0.4	79.31 +/- 0.94	80.02 +/- 0.77	79.52 +/- 0.8	78.2 +/- 0.58	82.47 +/- 0.87
Fstat	78.67 +/- 0.66	79.55 +/- 1.05	75.89 +/- 1.46	78.51 +/- 1.11	77.69 +/- 0.42	82.19 +/- 1.02
Gabor	81.95 +/- 1.22	81.87 +/- 1.19	80.73 +/- 1.19	81.11 +/- 0.65	81.55 +/- 1.21	85.7 +/- 0.95
Combination of features	87.95 +/- 0.78	87.42 +/- 1.11	87.76 +/- 0.88	86.83 +/- 0.75	87.48 +/- 0.91	90.35 +/- 0.11

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	82.22 +/- 0.93	82.8 +/- 1.31	81.31 +/- 0.93	83.0 +/- 0.71	81.88 +/- 0.59	85.87 +/- 0.86
Histogram	85.73 +/- 0.88	85.08 +/- 0.85	84.42 +/- 1.02	84.7 +/- 0.8	83.77 +/- 1.17	86.58 +/- 0.83
Fintesity	83.69 +/- 0.82	83.82 +/- 1.51	84.91 +/- 0.59	84.76 +/- 0.69	81.98 +/- 0.83	86.7 +/- 0.62
Fstat	83.92 +/- 0.87	83.93 +/- 0.28	82.81 +/- 1.81	83.76 +/- 1.11	80.81 +/- 1.08	86.68 +/- 1.19
Gabor	84.58 +/- 1.53	84.89 +/- 1.29	83.79 +/- 1.15	84.13 +/- 0.93	84.5 +/- 1.73	87.45 +/- 1.39
Combination of features	88.32 +/- 1.5	88.15 +/- 0.89	88.16 +/- 1.43	88.05 +/- 0.98	87.7 +/- 1.11	89.28 +/- 1.25

Histopathology: Reinard

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	77.97 +/- 0.68	77.9 +/- 1.09	75.65 +/- 1.22	77.17 +/- 1.3	78.61 +/- 0.81	81.94 +/- 0.87
Histogram	83.07 +/- 0.78	81.54 +/- 0.82	81.73 +/- 0.62	Influence of features is higher than color spaces		84.89 +/- 0.94
Fintesity	78.99 +/- 0.4	79.31 +/- 0.94	80.02 +/- 0.77			82.47 +/- 0.87
Fstat	78.67 +/- 0.66	79.55 +/- 1.05	75.89 +/- 1.46			82.19 +/- 1.02
Gabor	81.95 +/- 1.22	81.87 +/- 1.19	80.73 +/- 1.19			85.7 +/- 0.95
Combination of features	87.95 +/- 0.78	87.42 +/- 1.11	87.76 +/- 0.88	86.83 +/- 0.75	87.48 +/- 0.91	90.35 +/- 0.11

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	82.22 +/- 0.93	82.8 +/- 1.31	81.31 +/- 0.93	83.0 +/- 0.71	81.88 +/- 0.59	85.87 +/- 0.86
Histogram	85.73 +/- 0.88	85.08 +/- 0.85	84.42 +/- 1.02	84.7 +/- 0.8	83.77 +/- 1.17	86.58 +/- 0.83
Fintesity	83.69 +/- 0.82	83.82 +/- 1.51	84.91 +/- 0.59	84.76 +/- 0.69	81.98 +/- 0.83	86.7 +/- 0.62
Fstat	83.92 +/- 0.87	83.93 +/- 0.28	82.81 +/- 1.81	83.76 +/- 1.11	80.81 +/- 1.08	86.68 +/- 1.19
Gabor	84.58 +/- 1.53	84.89 +/- 1.29	83.79 +/- 1.15	84.13 +/- 0.93	84.5 +/- 1.73	87.45 +/- 1.39
Combination of features	88.32 +/- 1.5	88.15 +/- 0.89	88.16 +/- 1.43	88.05 +/- 0.98	87.7 +/- 1.11	89.28 +/- 1.25

Histopathology: Reinard

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	77.97 +/- 0.68	77.9 +/- 1.09	75.65 +/- 1.22	Combination of color spaces boost Gabor's performance		81.94 +/- 0.87
Histogram	83.07 +/- 0.78	81.54 +/- 0.82	81.73 +/- 0.62			84.89 +/- 0.94
Fintesity	78.99 +/- 0.4	79.31 +/- 0.94	80.02 +/- 0.77			82.47 +/- 0.87
Fstat	78.67 +/- 0.66	79.55 +/- 1.05	75.89 +/- 1.46	78.51 +/- 1.11	77.69 +/- 0.42	82.19 +/- 1.02
Gabor	81.95 +/- 1.22	81.87 +/- 1.19	80.73 +/- 1.19	81.11 +/- 0.65	81.55 +/- 1.21	85.7 +/- 0.95
Combination of features	87.95 +/- 0.78	87.42 +/- 1.11	87.76 +/- 0.88	86.83 +/- 0.75	87.48 +/- 0.91	90.35 +/- 0.11

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	82.22 +/- 0.93	82.8 +/- 1.31	81.31 +/- 0.93	83.0 +/- 0.71	81.88 +/- 0.59	85.87 +/- 0.86
Histogram	85.73 +/- 0.88	85.08 +/- 0.85	84.42 +/- 1.02	84.7 +/- 0.8	83.77 +/- 1.17	86.58 +/- 0.83
Fintesity	83.69 +/- 0.82	83.82 +/- 1.51	84.91 +/- 0.59	84.76 +/- 0.69	81.98 +/- 0.83	86.7 +/- 0.62
Fstat	83.92 +/- 0.87	83.93 +/- 0.28	82.81 +/- 1.81	83.76 +/- 1.11	80.81 +/- 1.08	86.68 +/- 1.19
Gabor	84.58 +/- 1.53	84.89 +/- 1.29	83.79 +/- 1.15	84.13 +/- 0.93	84.5 +/- 1.73	87.45 +/- 1.39
Combination of features	88.32 +/- 1.5	88.15 +/- 0.89	88.16 +/- 1.43	88.05 +/- 0.98	87.7 +/- 1.11	89.28 +/- 1.25

Histopathology: Reinard

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	77.97 +/- 0.68	77.9 +/- 1.09	75.65 +/- 1.22	77.17 +/- 1.3	78.61 +/- 0.81	81.94 +/- 0.87
Histogram	83.07 +/- 0.78	81.54 +/- 0.82	81.73 +/- 0.62	81.71 +/- 0.6	80.86 +/- 0.74	84.89 +/- 0.94
Fintesity	78.99 +/- 0.4	79.31 +/- 0.94	80.02 +/- 0.77	79.52 +/- 0.8	78.2 +/- 0.58	82.47 +/- 0.87
Fstat	78.67 +/- 0.66	79.55 +/- 1.05	75.89 +/- 1.46	78.51 +/- 1.11	77.69 +/- 0.42	82.19 +/- 1.02
Gabor	81.95 +/- 1.22	81.87 +/- 1.19	80.73 +/- 1.19	81.11 +/- 0.65	81.55 +/- 1.21	85.7 +/- 0.95
Combination of features	87.95 +/- 0.78	87.42 +/- 1.11	87.76 +/- 0.88	86.83 +/- 0.75	87.48 +/- 0.91	90.35 +/- 0.11

Global+Window

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	82.22 +/- 0.93	82.8 +/- 1.31	81.31 +/- 0.93	83.0 +/- 0.71	81.88 +/- 0.59	85.87 +/- 0.86
Histogram	85.73 +/- 0.88	85.08 +/- 0.85	84.42 +/- 1.02	84.7 +/- 0.8	83.77 +/- 1.17	86.58 +/- 0.83
Fintesity	83.69 +/- 0.82	83.82 +/- 1.51	84.91 +/- 0.59	84.76 +/- 0.69	81.98 +/- 0.83	86.7 +/- 0.62
Fstat	83.92 +/- 0.87	83.93 +/- 0.28	82.81 +/- 1.81	83.76 +/- 1.11	80.81 +/- 1.08	86.68 +/- 1.19
Gabor	84.58 +/- 1.53	84.89 +/- 1.29	83.79 +/- 1.15	84.13 +/- 0.93	84.5 +/- 1.73	87.45 +/- 1.39
Combination of features	88.32 +/- 1.5	88.15 +/- 0.89	88.16 +/- 1.43	88.05 +/- 0.98	87.7 +/- 1.11	89.28 +/- 1.25

Histopathology: Reinard

SVM

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	77.97 +/- 0.68	77.9 +/- 1.09	75.65 +/- 1.22	77.17 +/- 1.3	78.61 +/- 0.81	81.94 +/- 0.87
Histogram	83.07 +/- 0.78	81.54 +/- 0.82	81.73 +/- 0.62	81.71 +/- 0.6	80.86 +/- 0.74	84.89 +/- 0.94
Fintesity	78.99 +/- 0.4	79.31 +/- 0.94	80.02 +/- 0.77	79.52 +/- 0.8	78.2 +/- 0.58	82.47 +/- 0.87
Fstat	78.67 +/- 0.66	79.55 +/- 1.05	75.89 +/- 1.46	78.51 +/- 1.11	77.69 +/- 0.42	82.19 +/- 1.02
Gabor	81.95 +/- 1.22	81.87 +/- 1.19	80.73 +/- 1.19	81.11 +/- 0.65	81.55 +/- 1.21	85.7 +/- 0.95
Combination of features	87.95 +/- 0.78	87.42 +/- 1.11	87.76 +/- 0.88	86.83 +/- 0.75	87.48 +/- 0.91	90.35 +/- 0.11

Global+Window

Global

Random Forest

	Frgb	Fhsv	Flab	Fjch	Ftissue	Combination of color spaces
GLCM	82.22 +/- 0.93	82.8 +/- 1.31	81.31 +/- 0.93	83.0 +/- 0.71	81.88 +/- 0.59	85.87 +/- 0.86
Histogram	85.73 +/- 0.88	85.08 +/- 0.85	84.42 +/- 1.02	84.7 +/- 0.8	83.77 +/- 1.17	86.58 +/- 0.83
Fintesity	83.69 +/- 0.82	83.82 +/- 1.51	84.91 +/- 0.59	84.76 +/- 0.69	81.98 +/- 0.83	86.7 +/- 0.62
Fstat	83.92 +/- 0.87	83.93 +/- 0.28	82.81 +/- 1.81	83.76 +/- 1.11	80.81 +/- 1.08	86.68 +/- 1.19
Gabor	84.58 +/- 1.53	84.89 +/- 1.29	83.79 +/- 1.15	84.13 +/- 0.93	84.5 +/- 1.73	87.45 +/- 1.39
Combination of features	88.32 +/- 1.5	88.15 +/- 0.89	88.16 +/- 1.43	88.05 +/- 0.98	87.7 +/- 1.11	89.28 +/- 1.25

Dermo

SVM

	Frgb	Fhsv	Flab	Fjch	Fhybrid	Fsix	Combination of color spaces
GLCM	77.27 +/- 1.81	80.15 +/- 2.39	80.44 +/- 2.03	80.42 +/- 2.77	74.65 +/- 2.05	77.6 +/- 2.57	83.21 +/- 2.72
Histogram	73.54 +/- 2.06	77.17 +/- 1.67	76.29 +/- 1.57	78.79 +/- 0.88	71.31 +/- 0.43	76.21 +/- 1.42	79.56 +/- 1.68
Fintesity	79.12 +/- 1.1	78.1 +/- 2.0	80.77 +/- 1.86	79.25 +/- 1.9	71.12 +/- 2.35	75.58 +/- 1.92	80.94 +/- 2.65
Fstat	74.4 +/- 2.27	77.88 +/- 1.69	74.58 +/- 3.43	78.46 +/- 1.2	69.88 +/- 2.94	75.31 +/- 2.06	81.92 +/- 1.78
Gabor	78.1 +/- 2.89	79.17 +/- 2.38	79.02 +/- 2.67	77.81 +/- 1.95	71.6 +/- 2.72	77.31 +/- 3.14	81.31 +/- 2.17
Combination of features	85.71 +/- 0.93	87.0 +/- 1.4	87.19 +/- 1.33	86.79 +/- 0.58	78.35 +/- 2.16	83.69 +/- 3.67	88.19 +/- 0.65

Global+Window

Global

Random Forest

	Frgb	Fhsv	Flab	Fjch	Fhybrid	Fsix	Combination of color spaces
GLCM	77.52 +/- 2.4	80.25 +/- 2.54	79.23 +/- 2.73	79.38 +/- 2.19	72.35 +/- 1.92	76.02 +/- 2.97	82.44 +/- 3.33
Histogram	75.37 +/- 0.96	80.35 +/- 0.72	78.0 +/- 2.69	81.81 +/- 1.7	72.04 +/- 1.82	77.15 +/- 1.74	82.25 +/- 1.67
Fintesity	79.25 +/- 1.09	78.75 +/- 1.85	80.73 +/- 1.41	79.6 +/- 2.38	68.58 +/- 1.53	74.65 +/- 1.57	81.21 +/- 1.26
Fstat	73.19 +/- 1.23	78.46 +/- 1.85	73.54 +/- 2.92	78.5 +/- 2.09	68.44 +/- 2.8	73.9 +/- 1.65	81.1 +/- 2.04
Gabor	79.02 +/- 3.51	80.35 +/- 2.18	80.17 +/- 2.58	79.21 +/- 1.87	71.79 +/- 1.8	75.77 +/- 1.93	81.44 +/- 2.2
Combination of features	86.02 +/- 0.81	86.79 +/- 1.4	87.54 +/- 2.19	87.17 +/- 2.35	78.58 +/- 1.55	81.65 +/- 1.85	88.21 +/- 1.62

Dermo

SVM

	Frgb	Fhsv	Flab	Fjch	Fhybrid	Fsix	Combination of color spaces
GLCM	77.27 +/- 1.81	80.15 +/- 2.39	80.44 +/- 2.03	80.42 +/- 2.77	74.65 +/- 2.05	77.6 +/- 2.57	83.21 +/- 2.72
Histogram	73.54 +/- 2.06	77.17 +/- 1.67	76.29 +/- 1.57	78.79 +/- 0.88	71.31 +/- 0.43	76.21 +/- 1.42	79.56 +/- 1.68
Fintesity	79.12 +/- 1.1	78.1 +/- 2.0	80.77 +/- 1.86	79.25 +/- 1.9	71.12 +/- 2.35	75.58 +/- 1.92	80.94 +/- 2.65
Fstat	74.4 +/- 2.27	77.88 +/- 1.69	74.58 +/- 3.43	78.46 +/- 1.2	69.88 +/- 2.94	75.31 +/- 2.06	81.92 +/- 1.78
Gabor	78.1 +/- 2.89	79.17 +/- 2.38	79.02 +/- 2.67	77.81 +/- 1.95	71.6 +/- 2.72	77.31 +/- 3.14	81.31 +/- 2.17
Combination of features	85.71 +/- 0.93	87.0 +/- 1.4	87.19 +/- 1.33	86.79 +/- 0.58	78.35 +/- 2.16	83.69 +/- 3.67	88.19 +/- 0.65

Global+Window

Global

Random Forest

	Frgb	Fhsv	Flab	Fjch	Fhybrid	Fsix	Combination of color spaces
GLCM	77.52 +/- 2.4	80.25 +/- 2.54	79.23 +/- 2.73	79.38 +/- 2.19	72.35 +/- 1.92	76.02 +/- 2.97	82.44 +/- 3.33
Histogram	75.37 +/- 0.96	80.35 +/- 0.72	78.0 +/- 2.69	81.81 +/- 1.7	72.04 +/- 1.82	77.15 +/- 1.74	82.25 +/- 1.67
Fintesity	79.25 +/- 1.09	78.75 +/- 1.85	80.73 +/- 1.41	79.6 +/- 2.38	68.58 +/- 1.53	74.65 +/- 1.57	81.21 +/- 1.26
Fstat	73.19 +/- 1.23	78.46 +/- 1.85	73.54 +/- 2.92	78.5 +/- 2.09	68.44 +/- 2.8	73.9 +/- 1.65	81.1 +/- 2.04
Gabor	79.02 +/- 3.51	80.35 +/- 2.18	80.17 +/- 2.58	79.21 +/- 1.87	71.79 +/- 1.8	75.77 +/- 1.93	81.44 +/- 2.2
Combination of features	86.02 +/- 0.81	86.79 +/- 1.4	87.54 +/- 2.19	87.17 +/- 2.35	78.58 +/- 1.55	81.65 +/- 1.85	88.21 +/- 1.62

Dermo

SVM

	Frgb	Fhsv	Flab	Fjch	Fhybrid	Fsix	Combination of color spaces
GLCM	77.27 +/- 1.81	80.15 +/- 2.39	80.44 +/- 2.03	80.42 +/- 2.77	74.65 +/- 2.05	77.6 +/- 2.57	83.21 +/- 2.72
Histogram	73.54 +/- 2.06	77.17 +/- 1.67	76.29 +/- 1.57	78.79 +/- 0.88	71.31 +/- 0.43	76.21 +/- 1.42	79.56 +/- 1.68
Fintesity	79.12 +/- 1.1	78.1 +/- 2.0	80.77 +/- 1.86	79.25 +/- 1.9	71.12 +/- 2.35	75.58 +/- 1.92	80.94 +/- 2.65
Fstat	74.4 +/- 2.27	77.88 +/- 1.69	74.58 +/- 3.43	78.46 +/- 1.2	69.88 +/- 2.94	75.31 +/- 2.06	81.92 +/- 1.78
Gabor	78.1 +/- 2.89	79.17 +/- 2.38	79.02 +/- 2.67	77.81 +/- 1.95	71.6 +/- 2.72	77.31 +/- 3.14	81.31 +/- 2.17
Combination of features	85.71 +/- 0.93	87.0 +/- 1.4	87.19 +/- 1.33	86.79 +/- 0.58	78.35 +/- 2.16	83.69 +/- 3.67	88.19 +/- 0.65

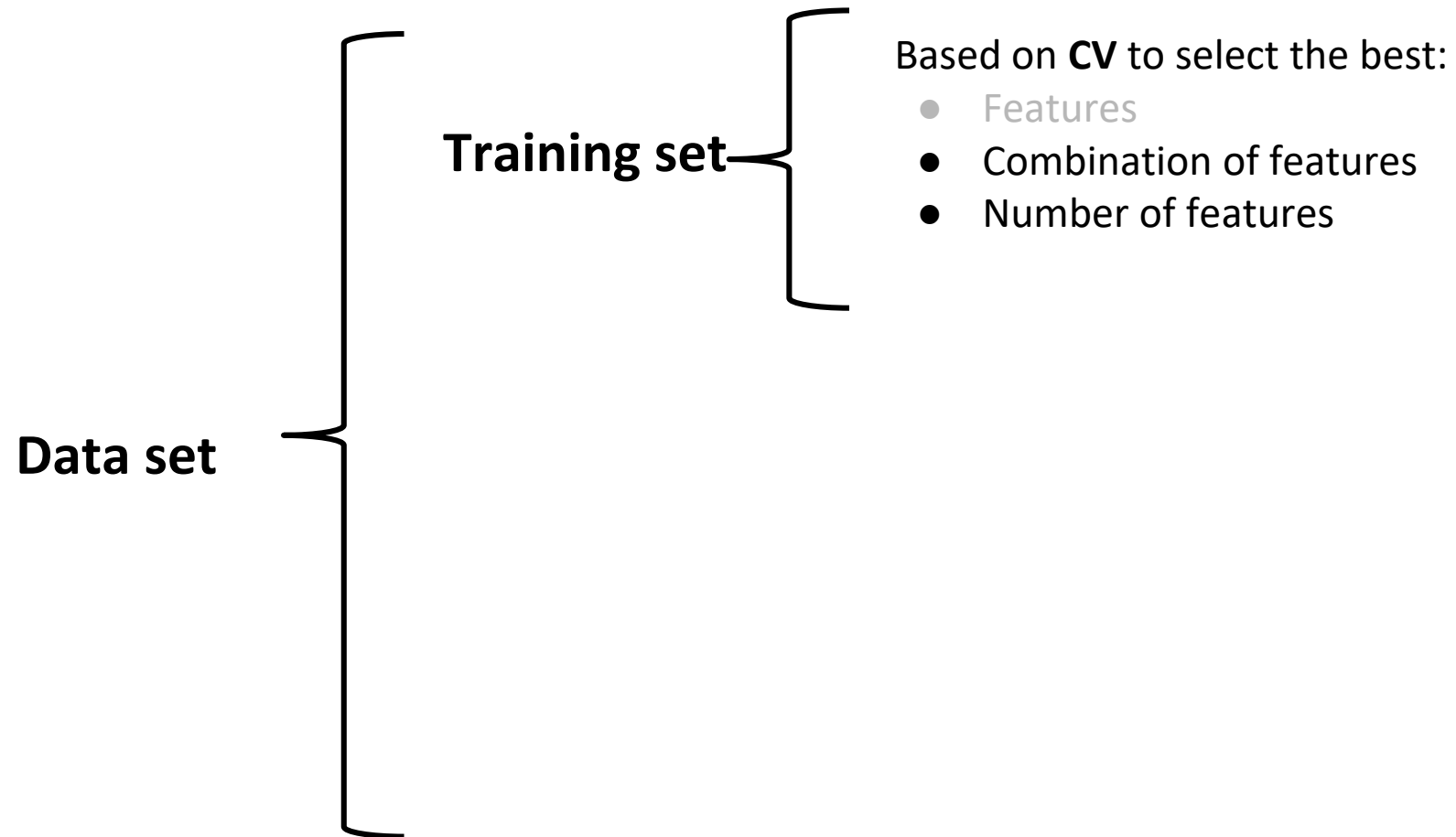
Global+Window

Global

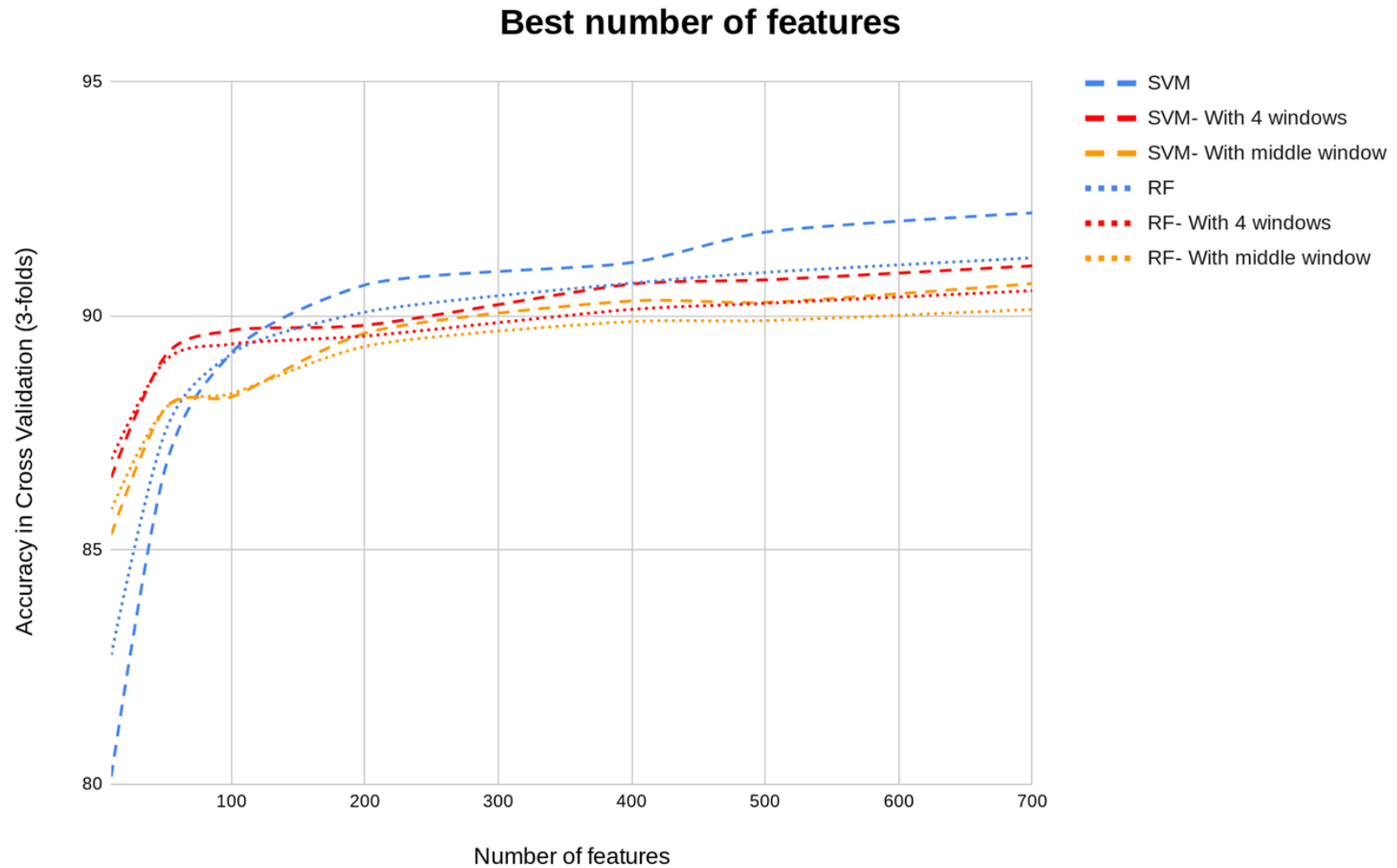
Random Forest

	Frgb	Fhsv	Flab	Fjch	Fhybrid	Fsix	Combination of color spaces
GLCM	77.52 +/- 2.4	80.25 +/- 2.54	79.23 +/- 2.73	79.38 +/- 2.19	72.35 +/- 1.92	76.02 +/- 2.97	82.44 +/- 3.33
Histogram	75.37 +/- 0.96	80.35 +/- 0.72	78.0 +/- 2.69	81.81 +/- 1.7	72.04 +/- 1.82	77.15 +/- 1.74	82.25 +/- 1.67
Fintesity	79.25 +/- 1.09	78.75 +/- 1.85	80.73 +/- 1.41	79.6 +/- 2.38	68.58 +/- 1.53	74.65 +/- 1.57	81.21 +/- 1.26
Fstat	73.19 +/- 1.23	78.46 +/- 1.85	73.54 +/- 2.92	78.5 +/- 2.09	68.44 +/- 2.8	73.9 +/- 1.65	81.1 +/- 2.04
Gabor	79.02 +/- 3.51	80.35 +/- 2.18	80.17 +/- 2.58	79.21 +/- 1.87	71.79 +/- 1.8	75.77 +/- 1.93	81.44 +/- 2.2
Combination of features	86.02 +/- 0.81	86.79 +/- 1.4	87.54 +/- 2.19	87.17 +/- 2.35	78.58 +/- 1.55	81.65 +/- 1.85	88.21 +/- 1.62

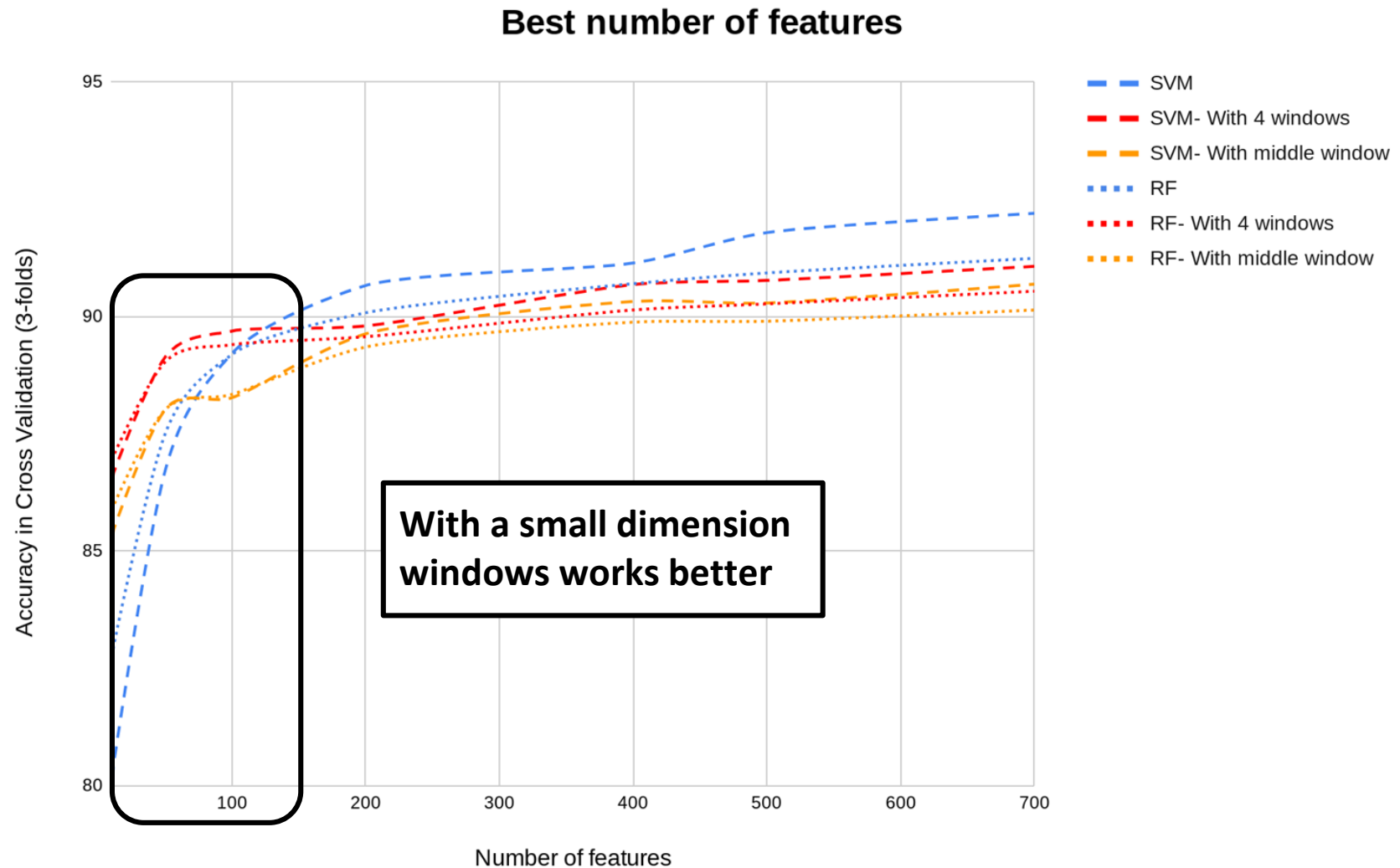
Experiments



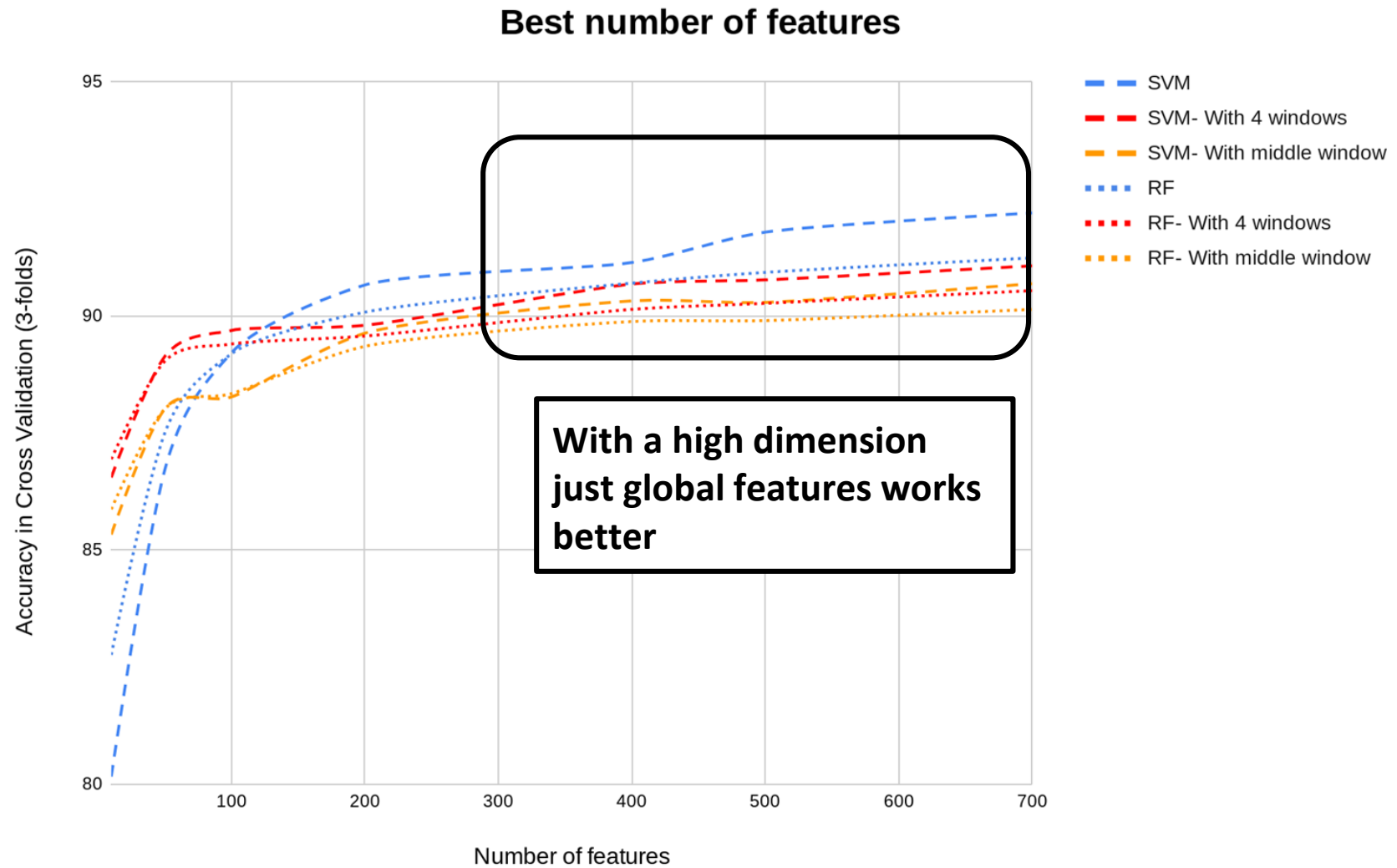
Histopathology



Histopathology



Histopathology



Candidate models

		10 features	50 features	100 features	200 features	400 features	500 features	700 features
SVM	Without window	80.16	86.7	89.21	90.66	91.14	91.79	92.2
	With 4 windows	86.55	89.13	89.69	89.8	90.68	90.77	91.07
	With middle window	85.33	88.01	88.27	89.63	90.32	90.29	90.69
RF	Without window	82.76	87.49	89.19	90.08	90.7	90.93	91.24
	With 4 windows	86.94	89.03	89.4	89.57	90.14	90.27	90.54
	With middle window	85.87	88.01	88.34	89.35	89.88	89.9	90.14

*Feature selection is ANOVA

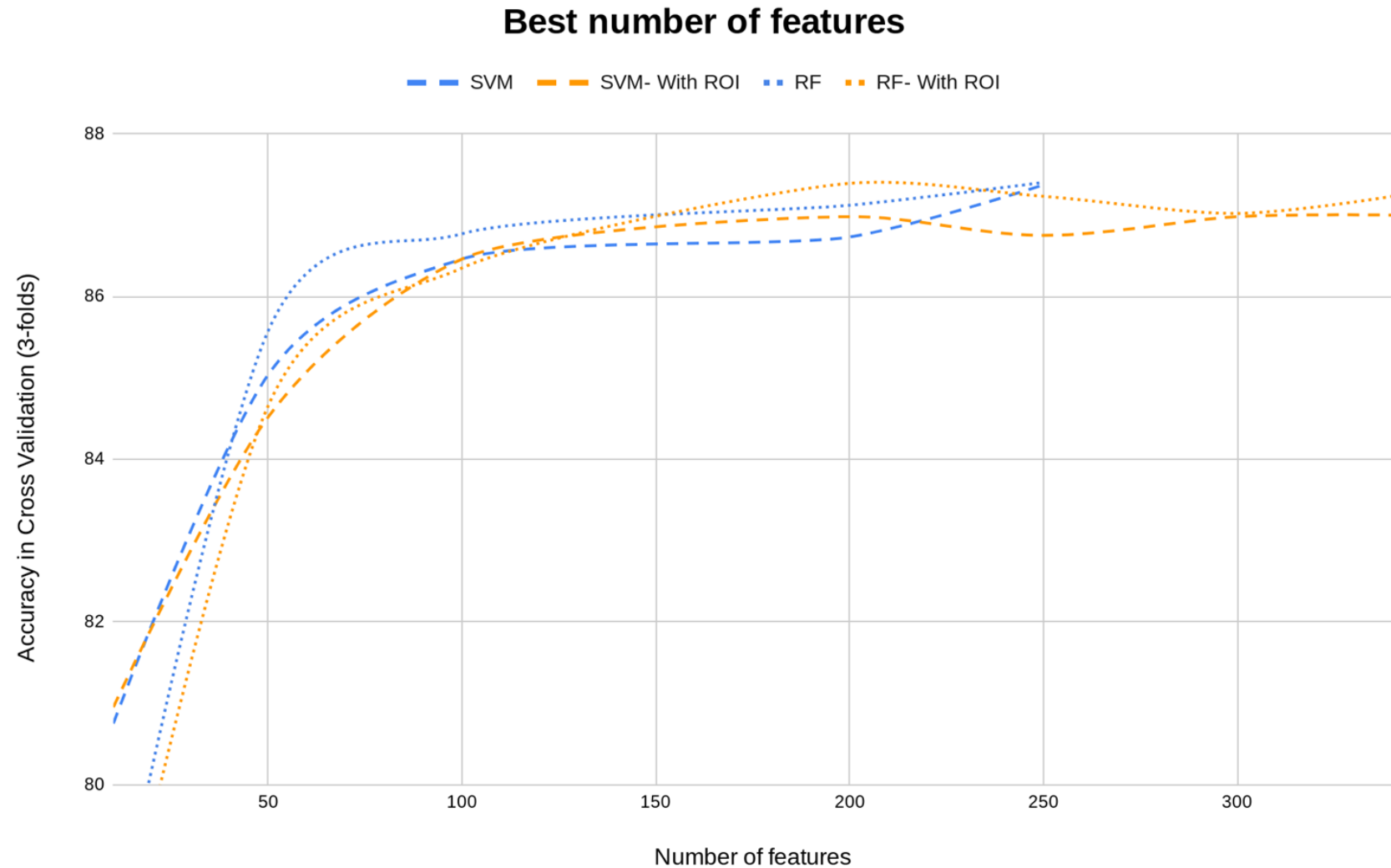
Others experiments

mRMR. Computational expensive and low performance (>85.83%).

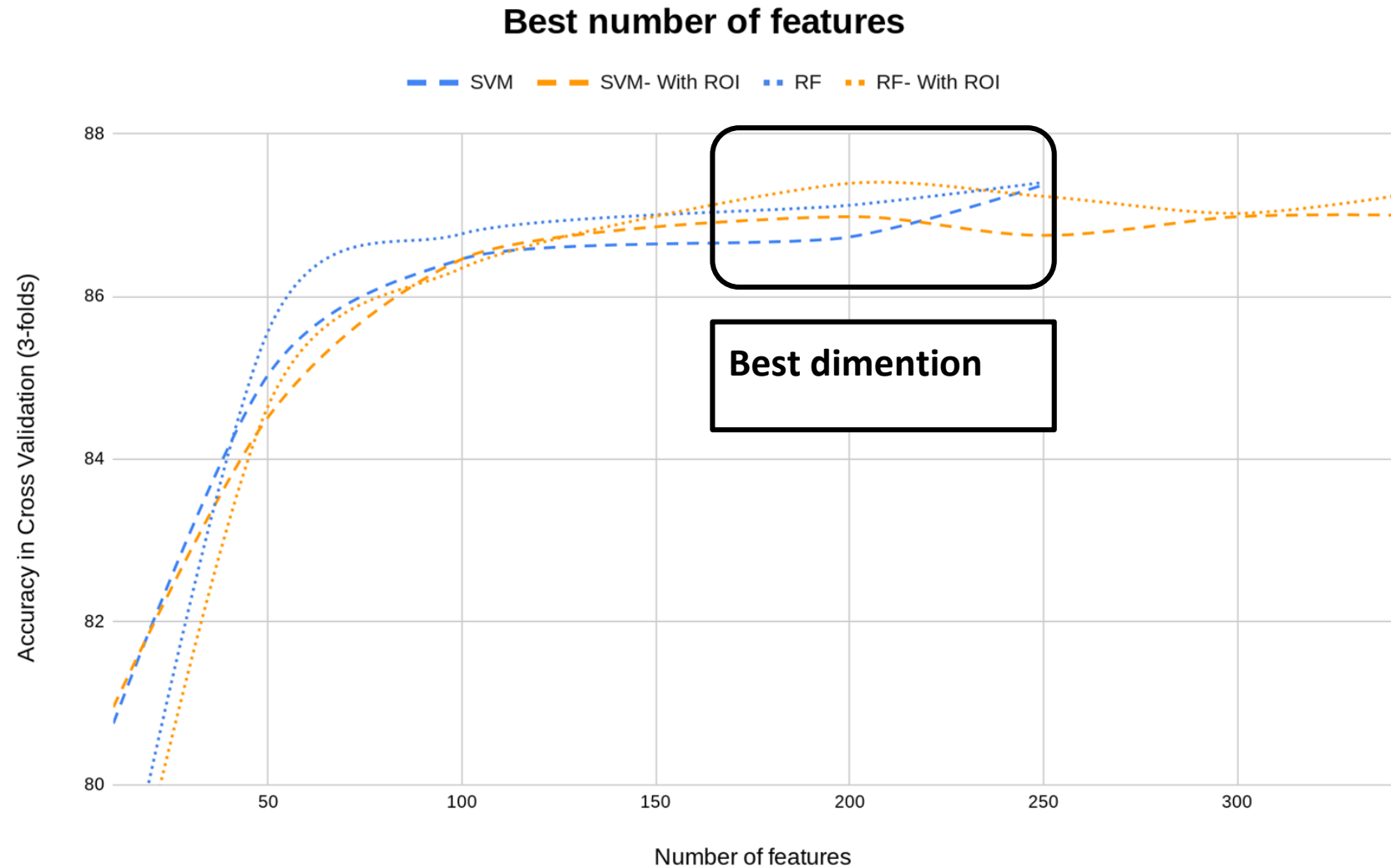
Random Forest without feature selection
91.16%.

L2 Normalization. Low performance (>82%)

Dermo



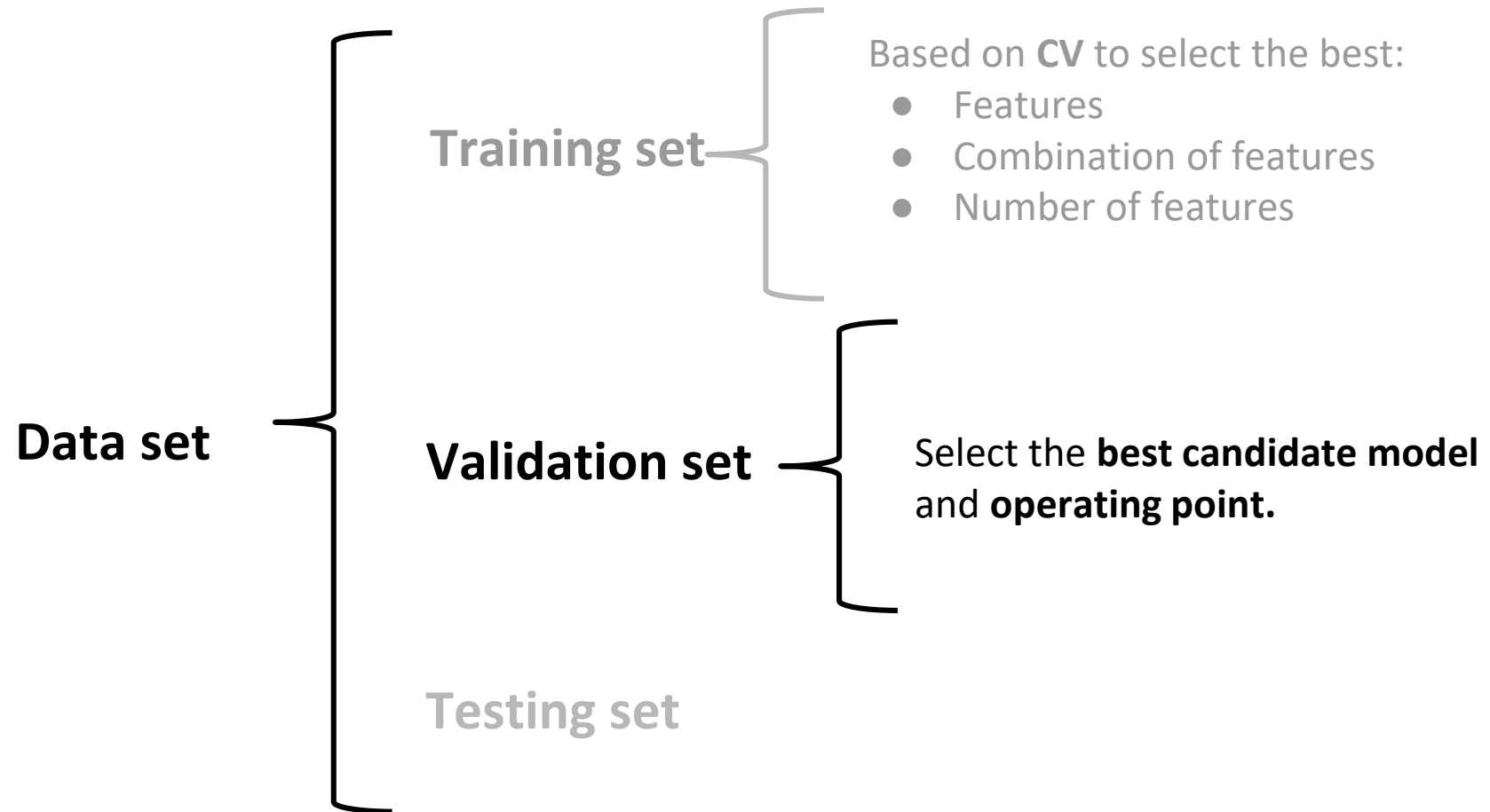
Dermo



Candidate models

	10	50	100	200	250	300	340
SVM	80.75	85.04	86.46	86.73	87.37		
SVM- With ROI	80.95	84.52	86.46	86.98	86.75	86.98	87
RF	78	85.58	86.77	87.12	87.4		
RF- With ROI	77.52	84.66	86.35	87.39	87.23	87.02	87.23

Experiments

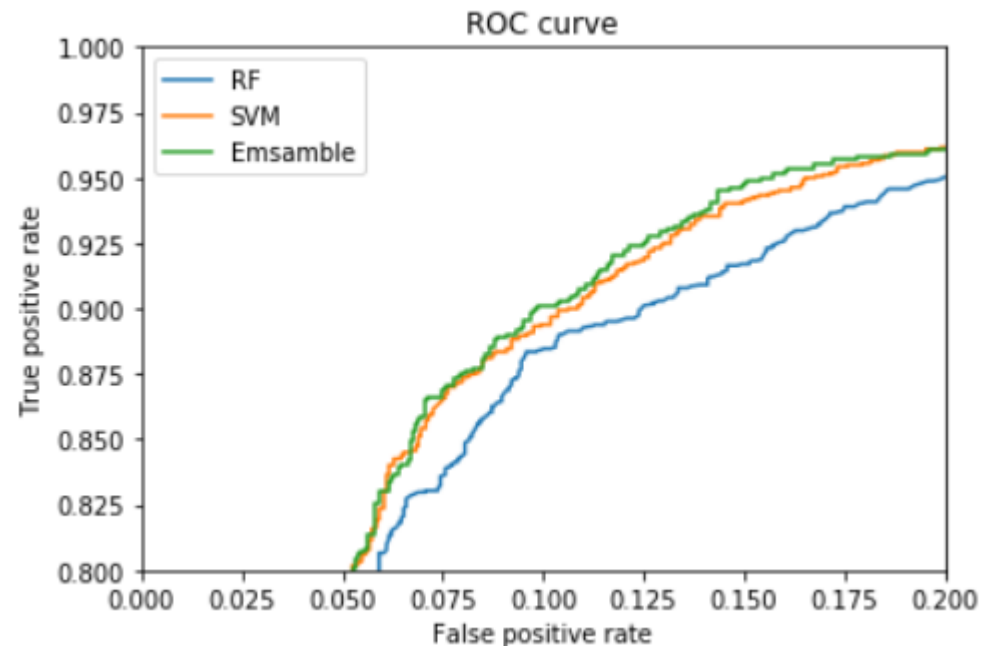
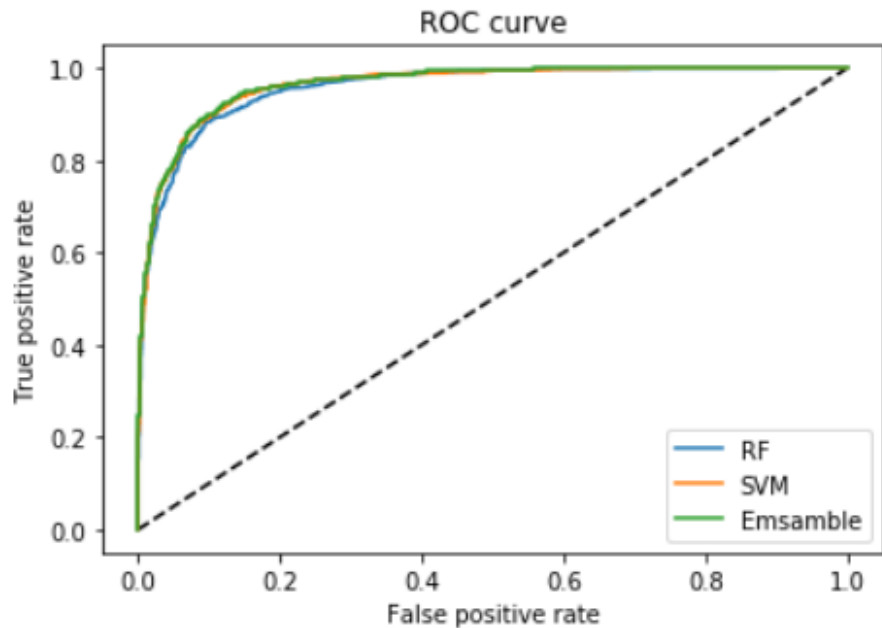


Histopathology

Performance in validation of the selected models

			Accuracy	Sensitivity	Specificity
SVM	Without window	200 features	0.88	0.89	0.86
		700 features	0.9	0.92	0.88
	4 windows	50 features	0.87	0.88	0.86
RF	Without window	700 features	0.88	0.91	0.86
	Middle window	200 features	0.88	0.9	0.86
	4 windows	100 features	0.87	0.89	0.85

Histopathology



$$\text{probEnsemble} = (2 * \text{probSVM} + 1 * \text{probRF})$$

AUC for RF 95,78%

AUC for SVM 96,29%

AUC for Ensemble 96,43%

Histopathology

Mean of validation probabilities is 0.46 -> **Bias** in the **classifier**

With a prediction threshold of 0.5, the mean of our prediction is 46.94%. The classifier trends to detect the **benignant** cases than the malignant-> Need to find an **optimal threshold**

For a operating point of 0.4 (50.1%)

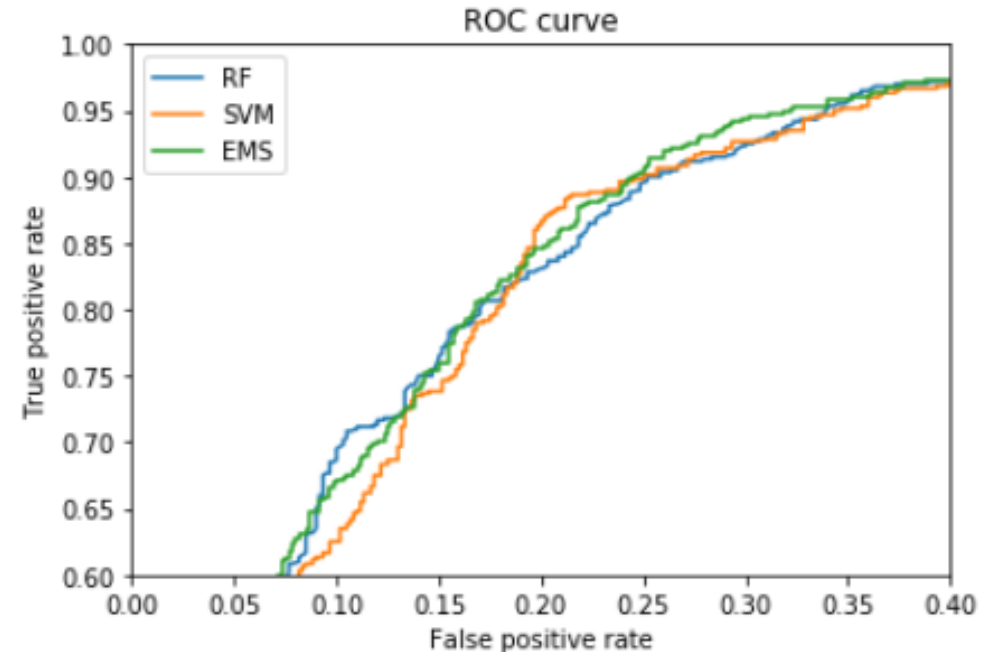
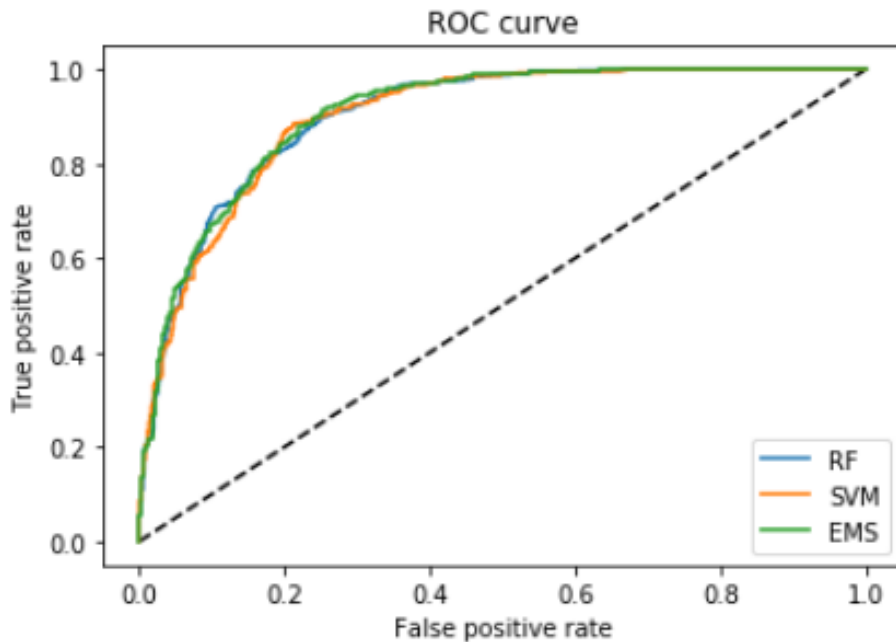
Accuracy (%)	Sensitivity (%)	Specificity (%)	AUC (%)
90.05	90.15	89.96	96,43

Performance in validation of the selected models

		Accuracy	Sensitivity	Specificity
SVM	Without window (250 features)	0.81	0.75	0.89
	With ROI (200 features)	0.81	0.75	0.9
RF	Without window (250 features)	0.81	0.94	0.74
	With ROI (200 features)	0.81	0.74	0.92

Less features, same performance

Dermo



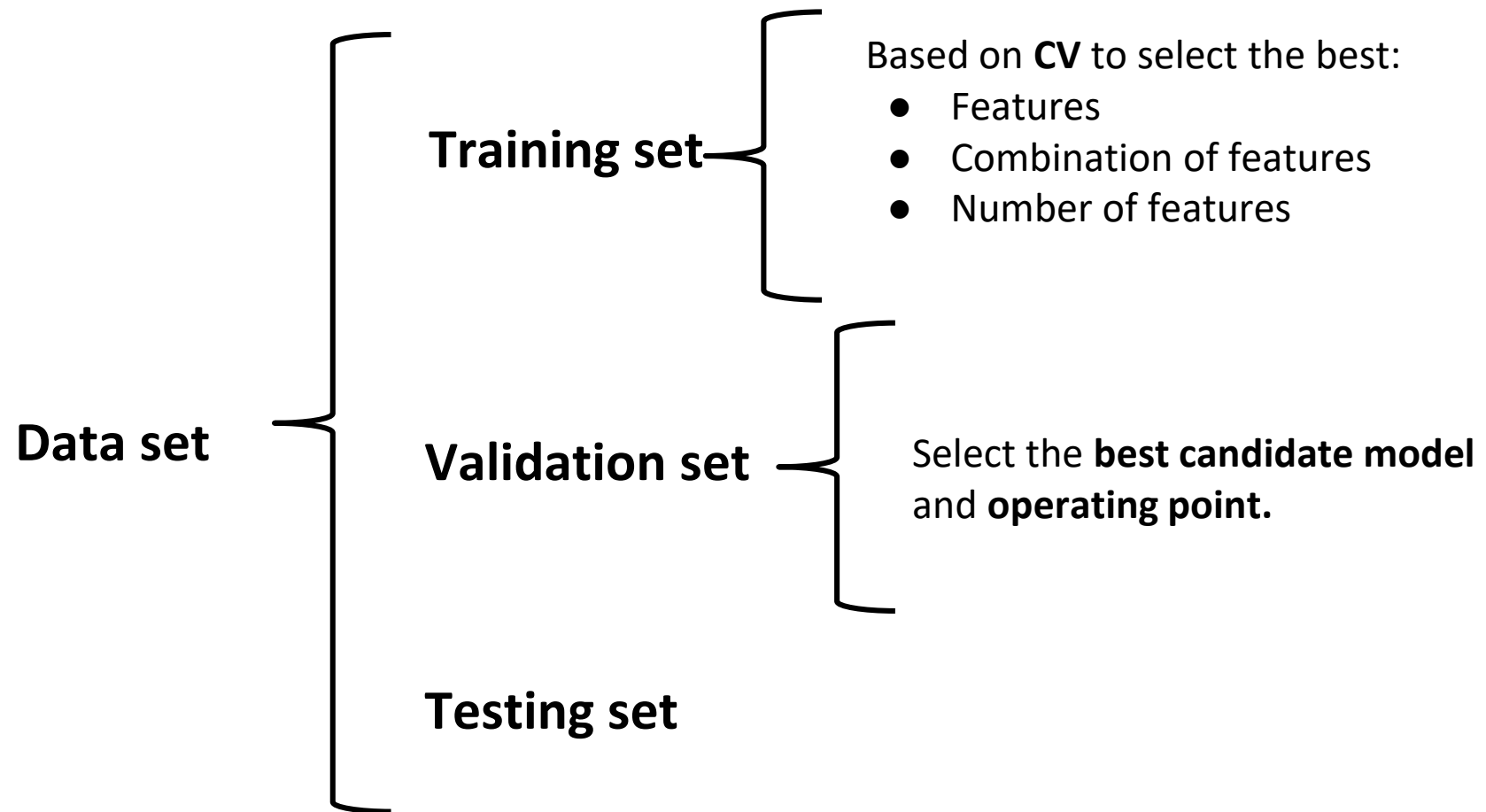
$\text{probEnsemble} = (\text{probSVM} + \text{probRF})$

AUC for RF 90.30
 AUC for SVM 90.09
 AUC for Ensemble 90.63

Dermo

Accuracy (%)	Sensitivity (%)	Specificity (%)	AUC (%)
82.75	78.35	88.75	90.63

Experiments



Conclusions

- Feature extraction is computationally expensive
- Simple approach works fine
- There is not a very discriminant feature, the combination of a group of them is needed.
- Ensemble methods boost the performance and help us to avoid overfitting.
- General approaches can be used for differences applications, at the end we are looking at the numbers behind the diseases, not the diseases itself.

Questions

