

Enhancing Oral Diagnostics with Hyperspectral Imaging and Deep Learning:

Mucosa Segmentation and Preliminary Findings on Carcinoma Detection

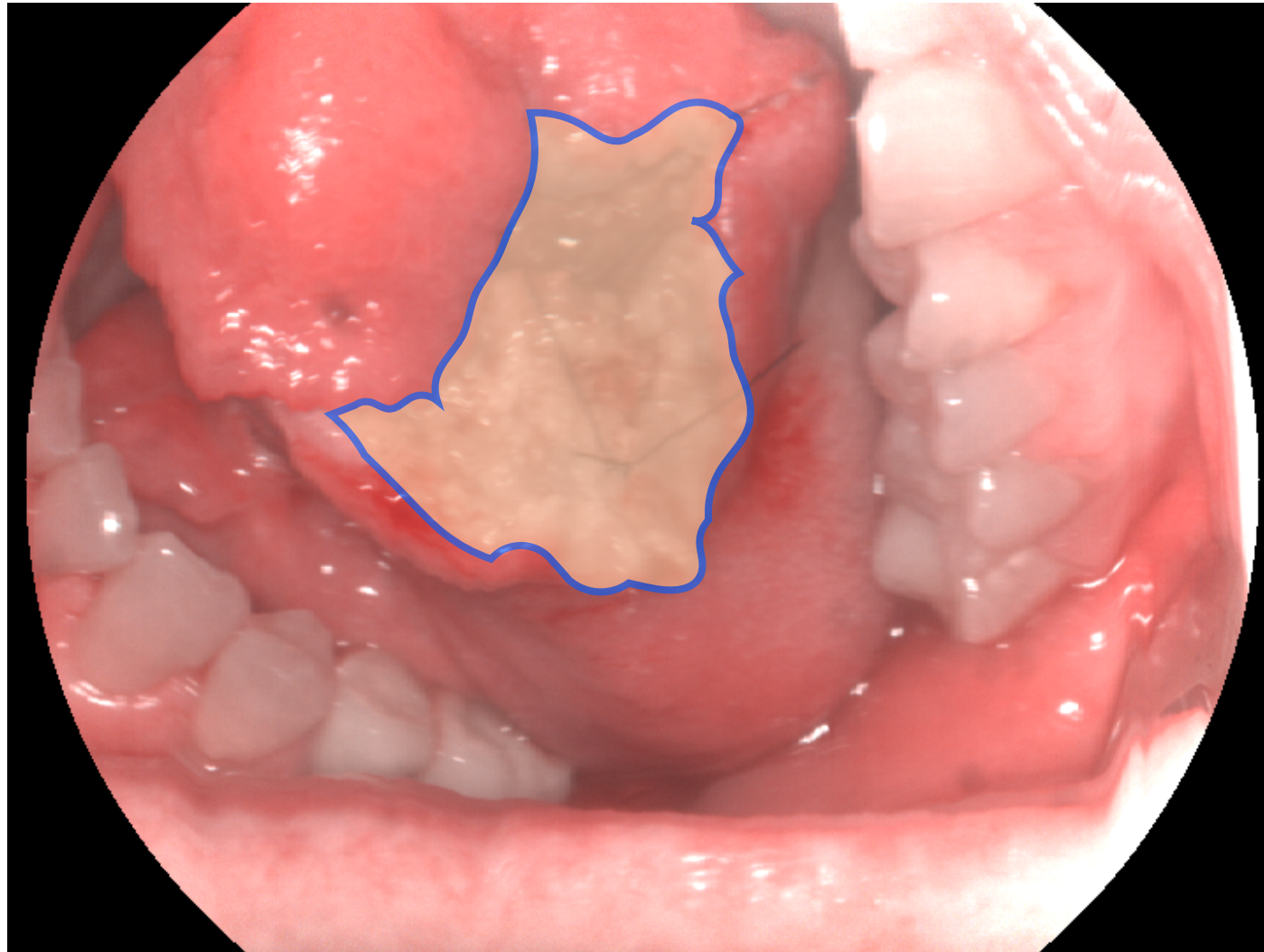
350,000

Purpose of the Research: early detection of carcinoma tumor

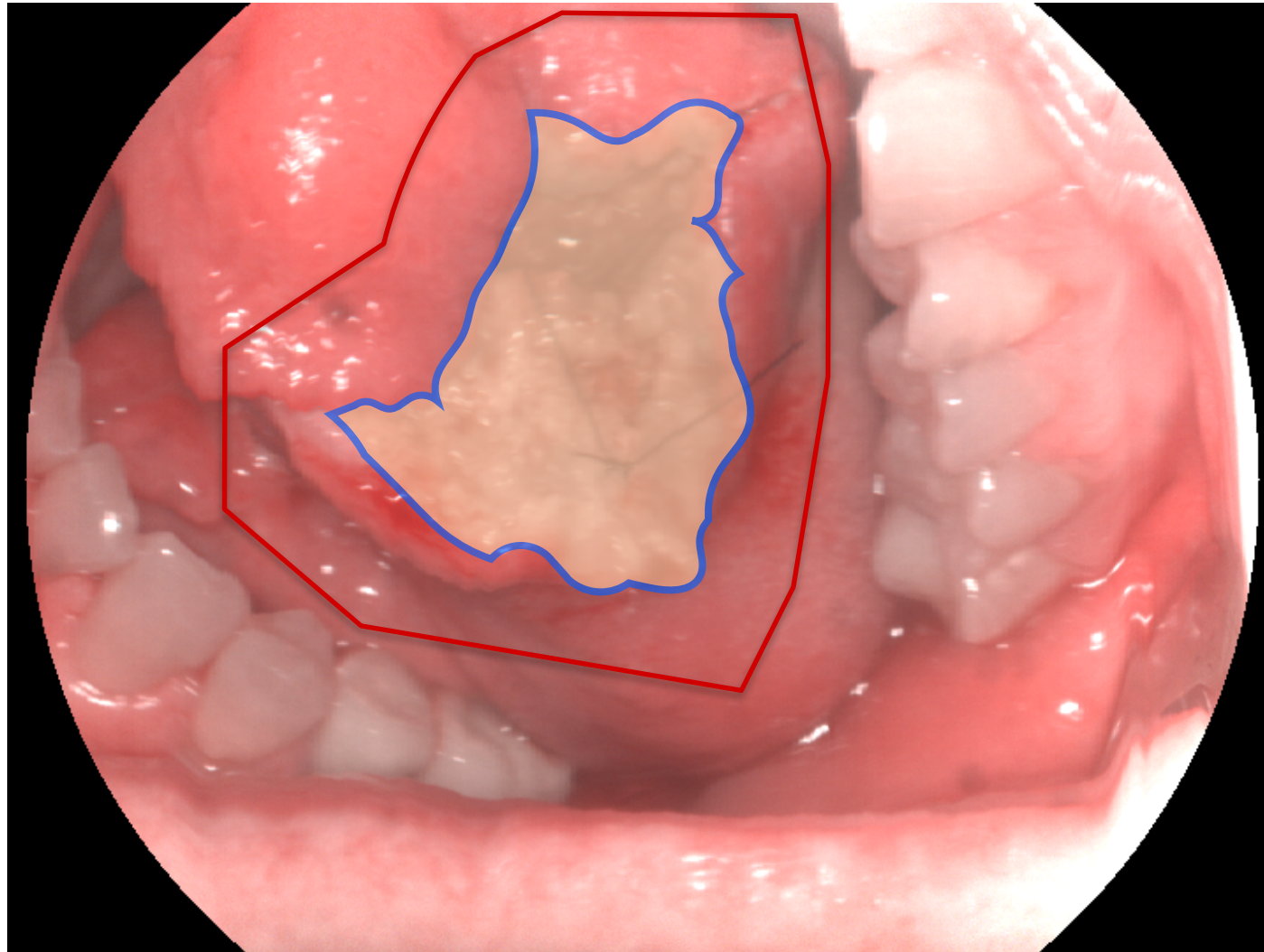
- 350,000 new cases / year
- 60% 5-year survival rate
- 30% Recidivism rate
- 50% of diagnoses in advanced stages
- Surgery as primary therapy is the current standard



Purpose of the Research: early detection of carcinoma tumor

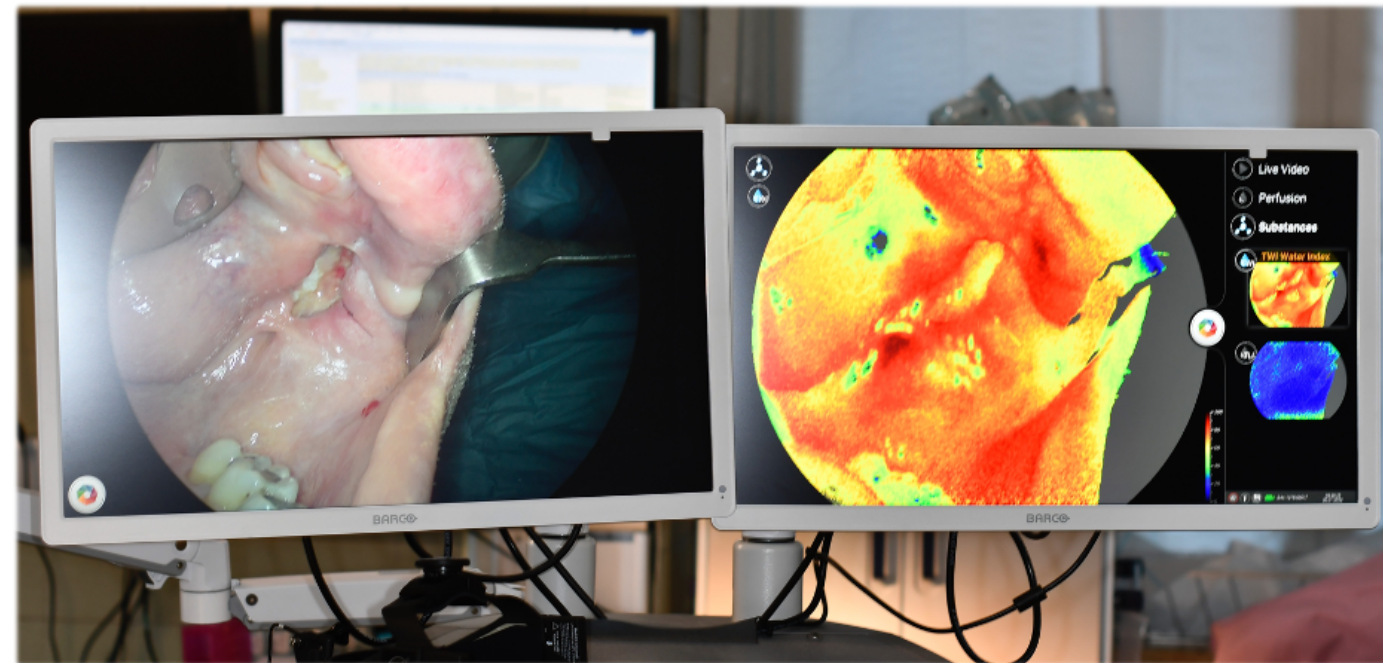
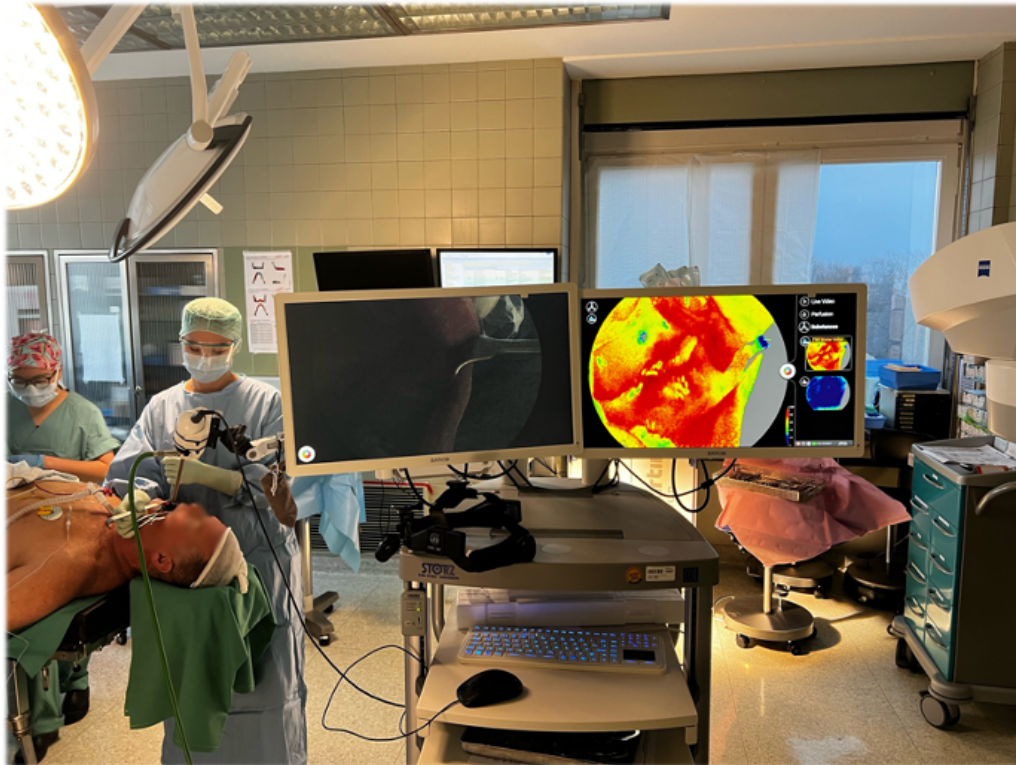


Purpose of the Research: early detection of carcinoma tumor



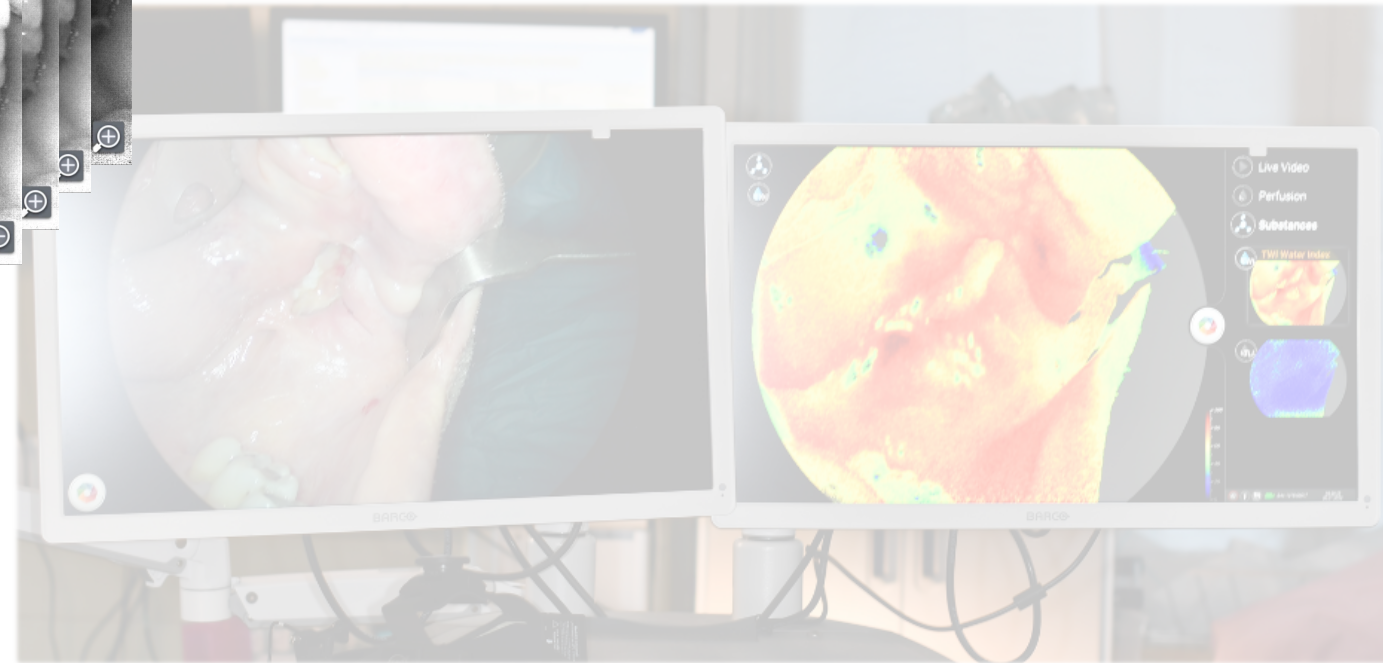
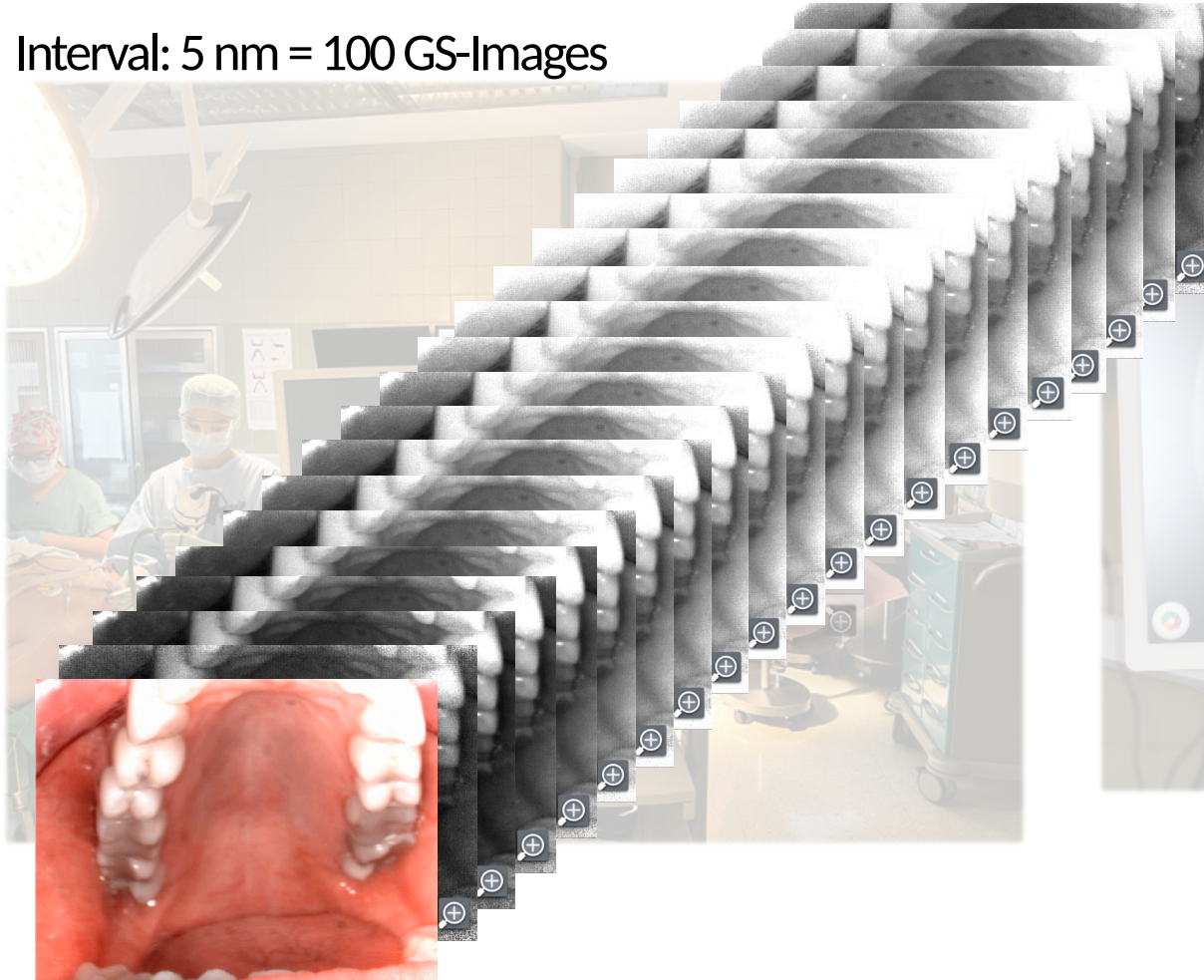
1 cm margin

Purpose of the Research: early detection of carcinoma tumor



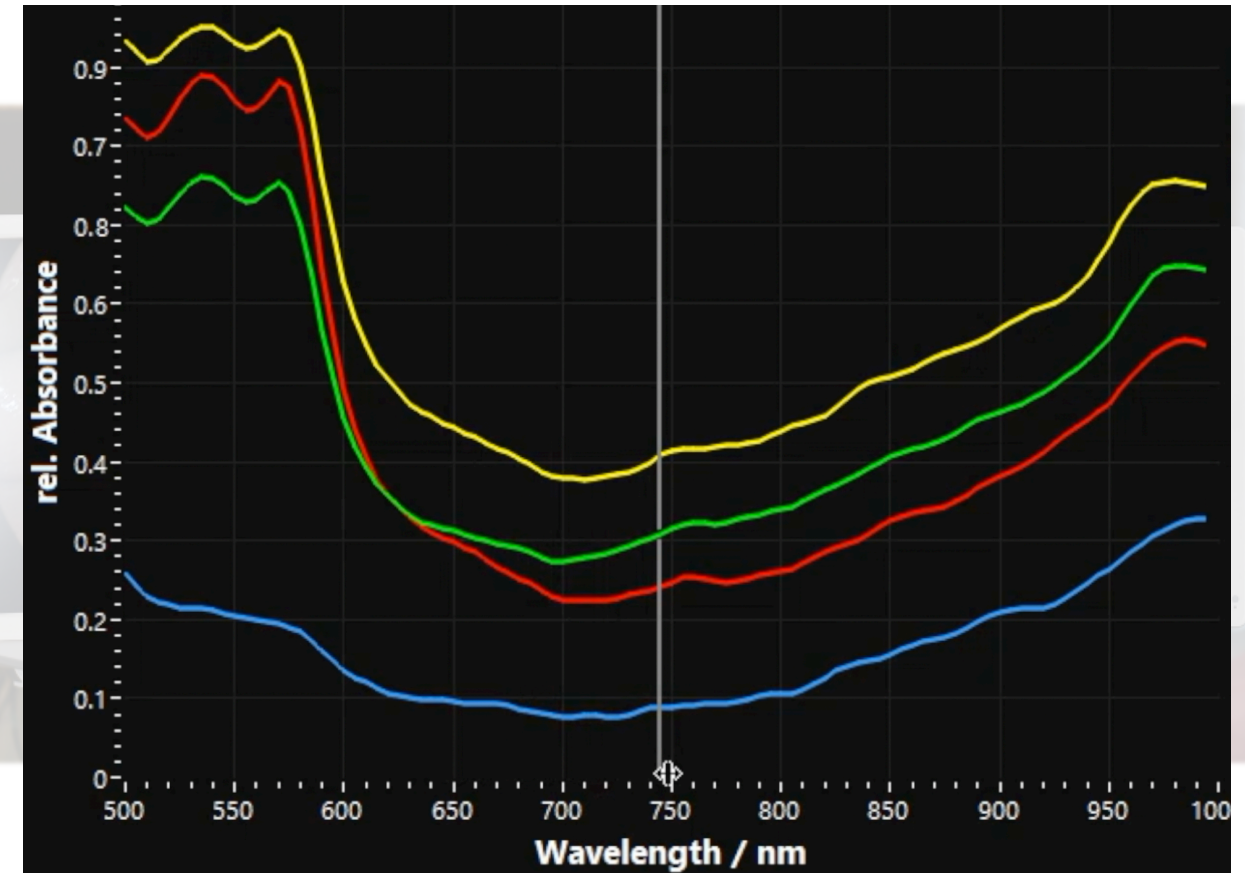
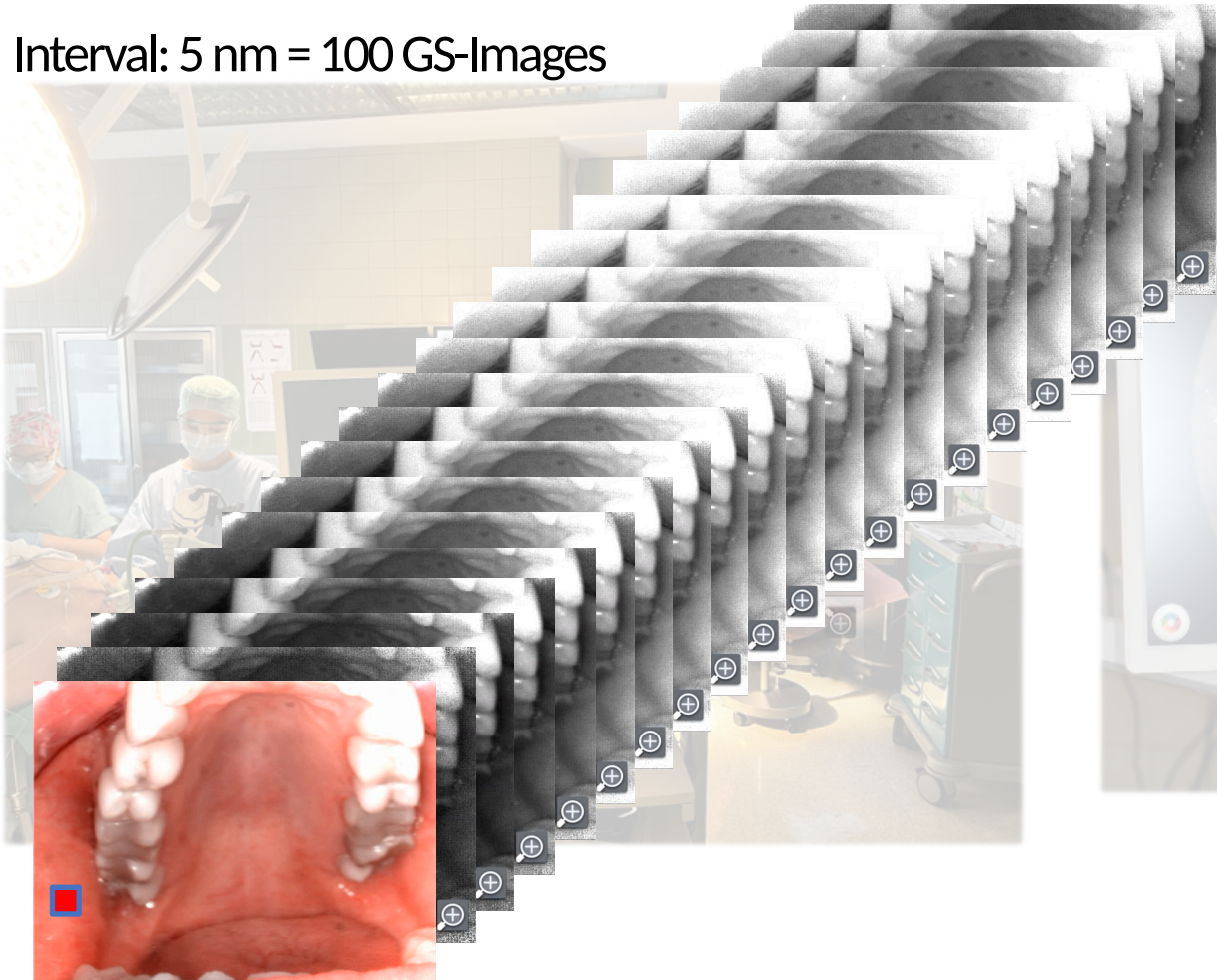
Purpose of the Research: early detection of carcinoma tumor

Interval: 5 nm = 100 GS-Images



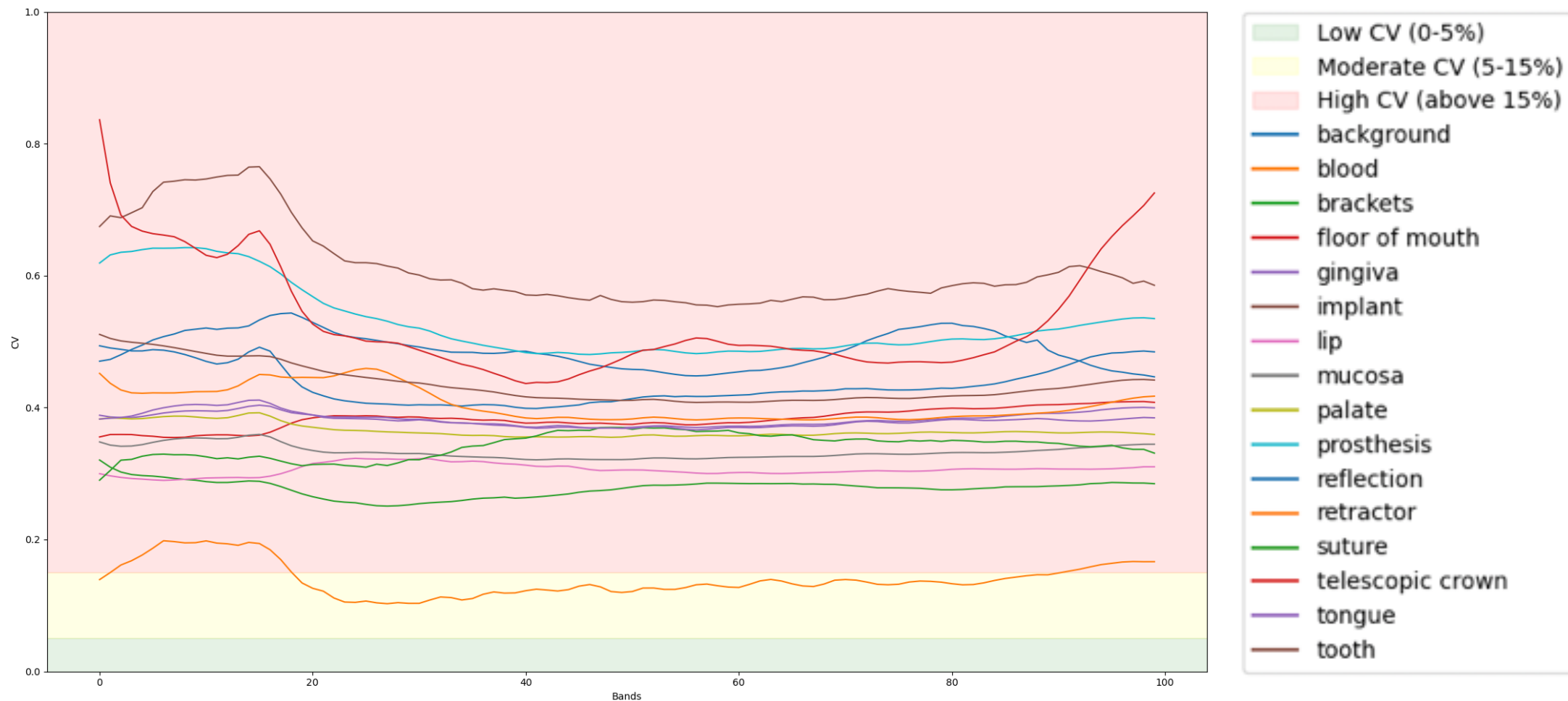
Purpose of the Research: early detection of carcinoma tumor

Interval: 5 nm = 100 GS-Images



Acquisition *Analysis*

- High coefficient of variation (CV)
- Class identification based only on its signature is impractical
- Excluding reliance on ad hoc solutions

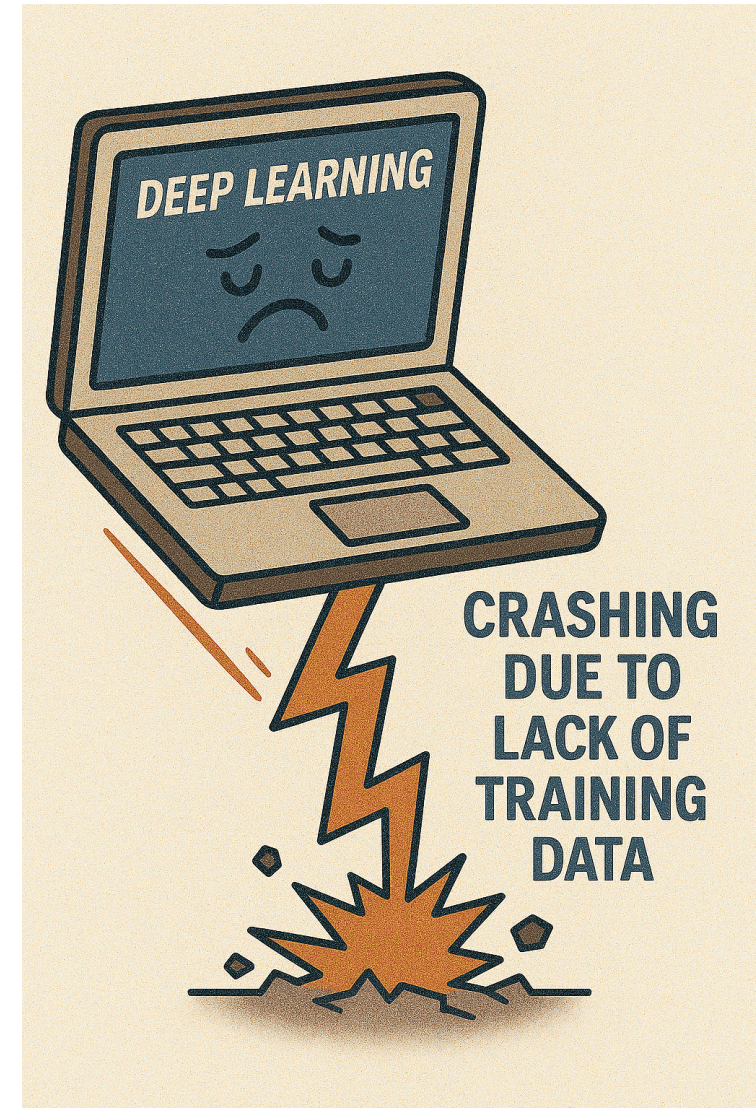


Deep Learning our only chance?



We had only a few samples

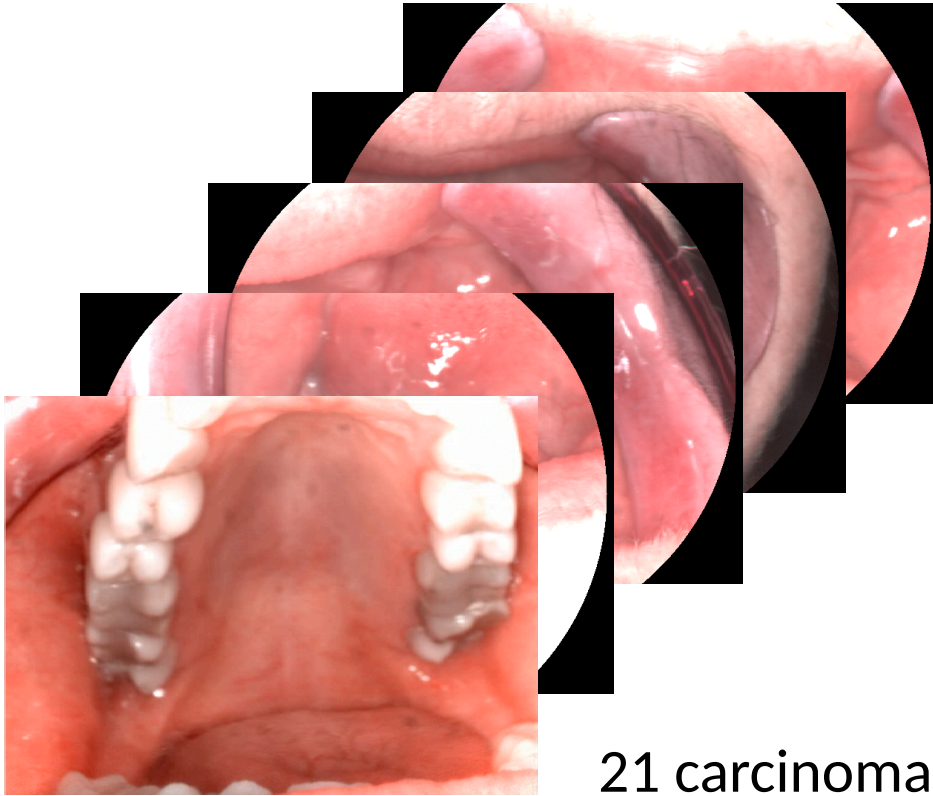
Only 21 cases with carcinoma
tumor for more than 752 patients
without tumor



Multiple datasets...One possibility?

1

In-Vivo Oral Cavity Scan

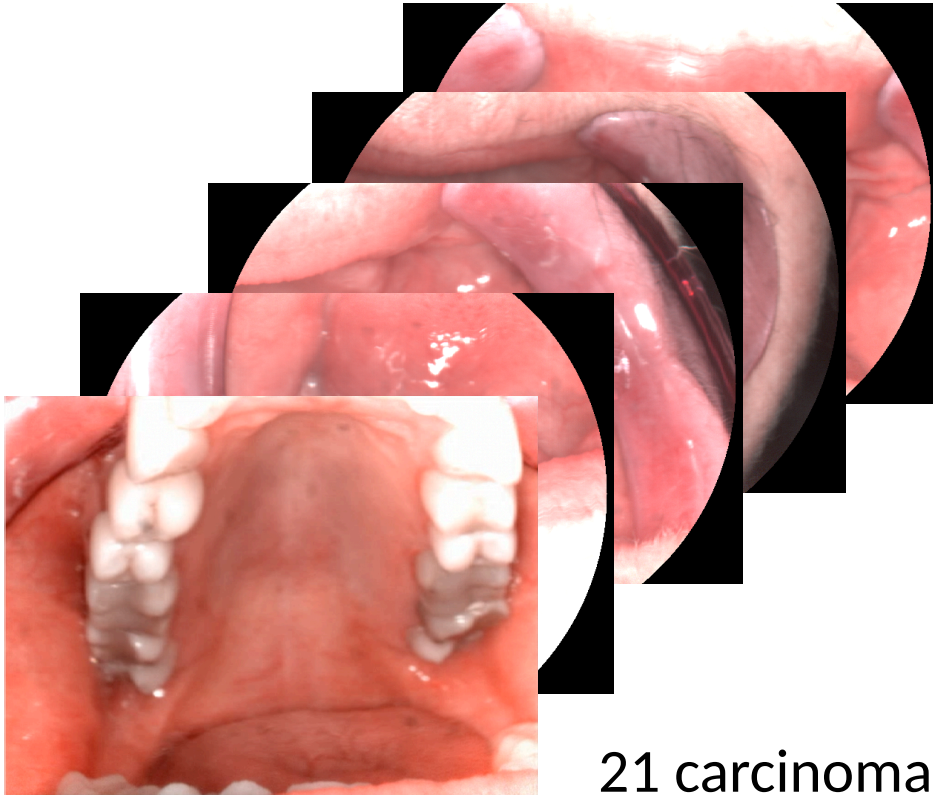


21 carcinoma-positive
752 non-carcinoma

Multiple datasets...One possibility?

1

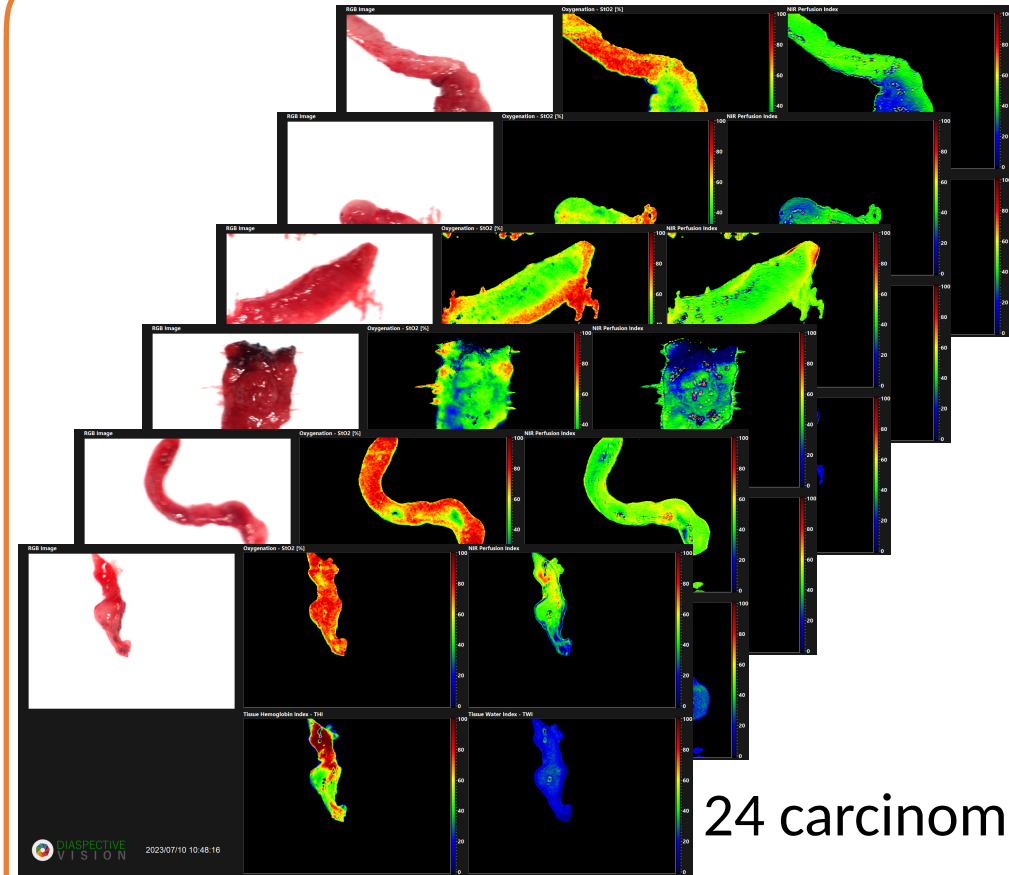
In-Vivo Oral Cavity Scan



21 carcinoma-positive
 752 non-carcinoma

2

Ex-Vivo Frozen Section

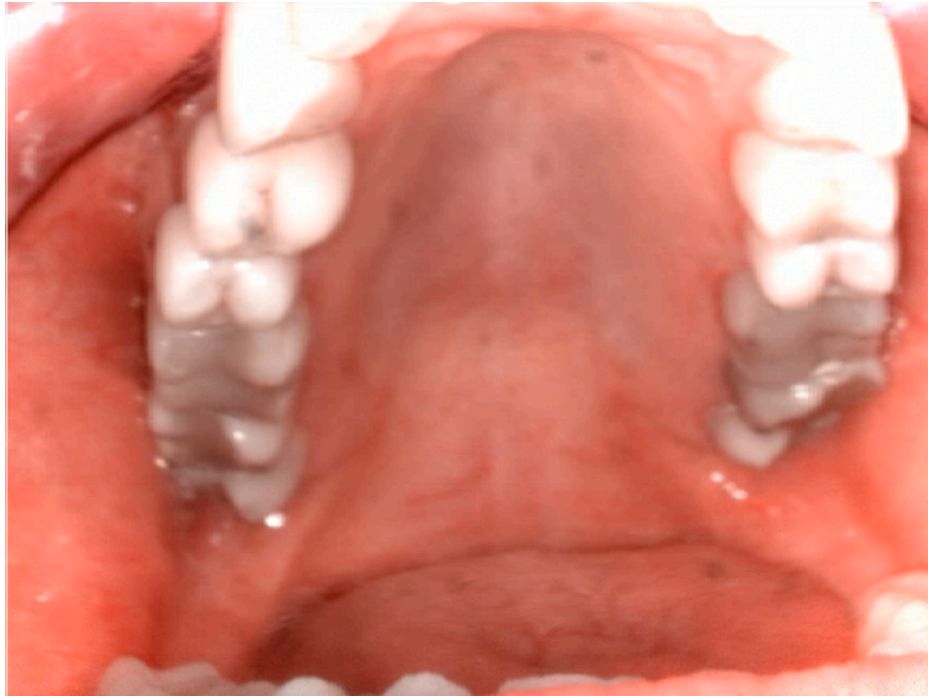


24 carcinoma-positive
 200 non-carcinoma

Multiple datasets...One possibility?

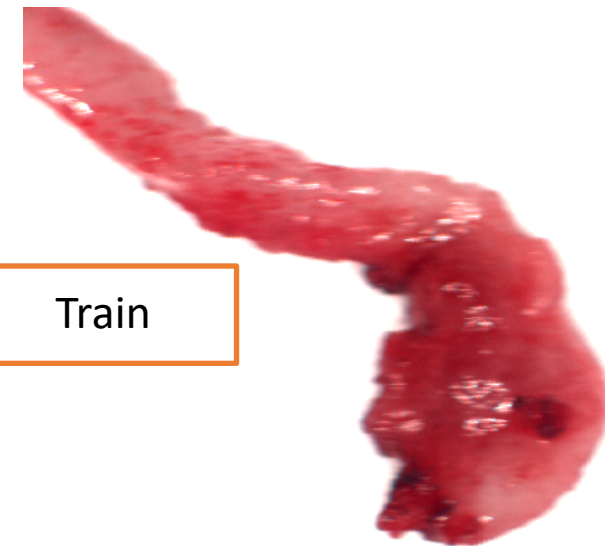
1

In-Vivo Oral Cavity Scan



2

Ex-Vivo Frozen Section

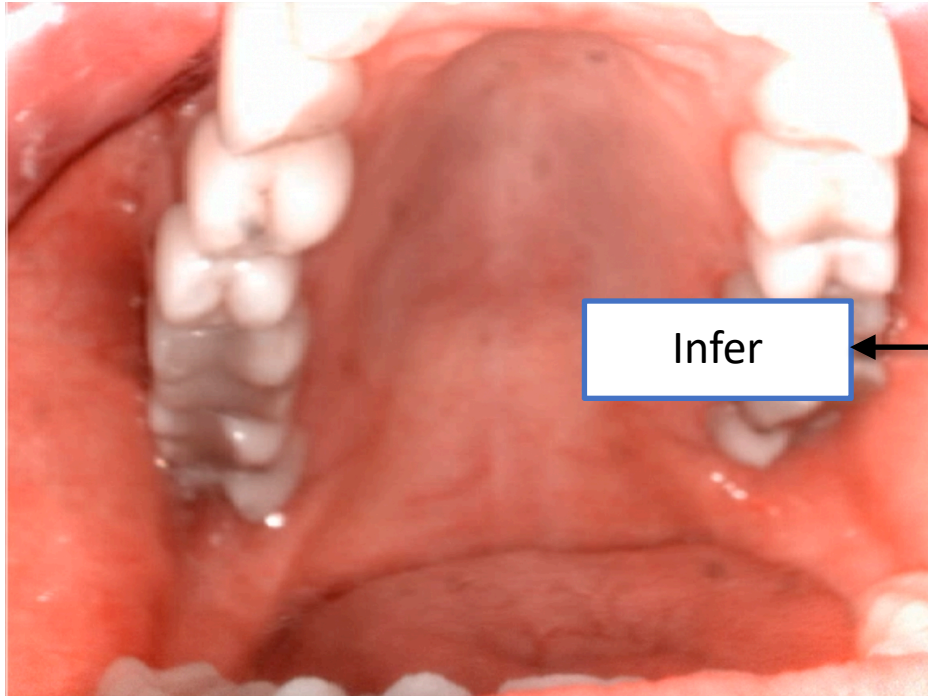


Train

Multiple datasets...One possibility?

1

In-Vivo Oral Cavity Scan



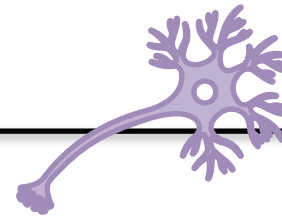
Infer

2

Ex-Vivo Frozen Section



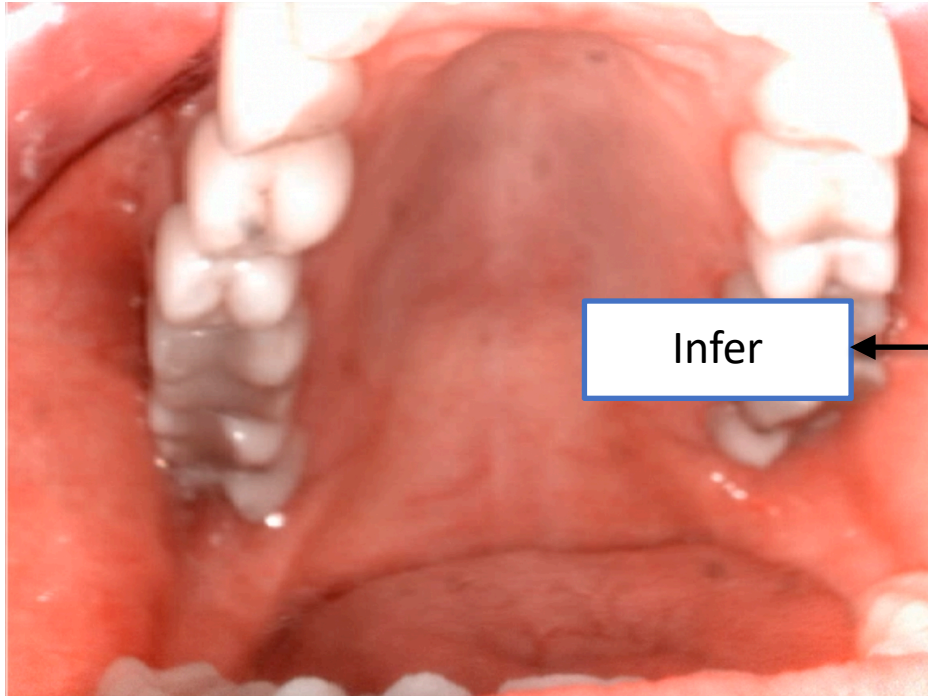
Train



Multiple datasets...One possibility?

1

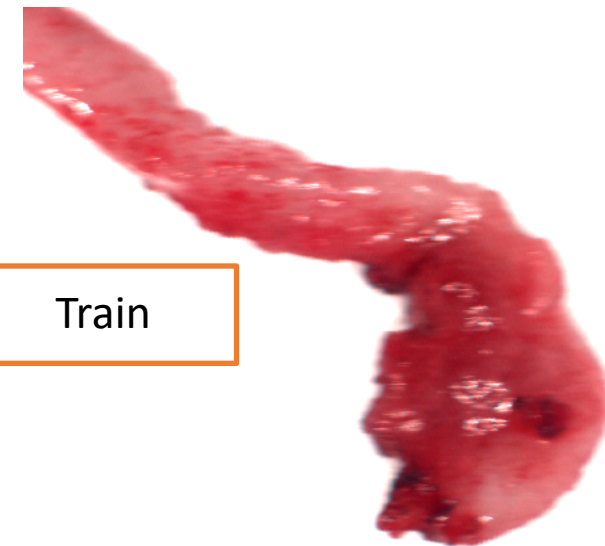
In-Vivo Oral Cavity Scan



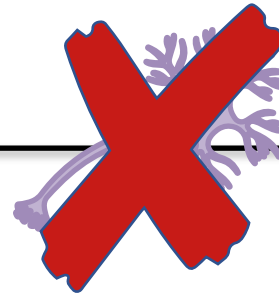
Infer

2

Ex-Vivo Frozen Section

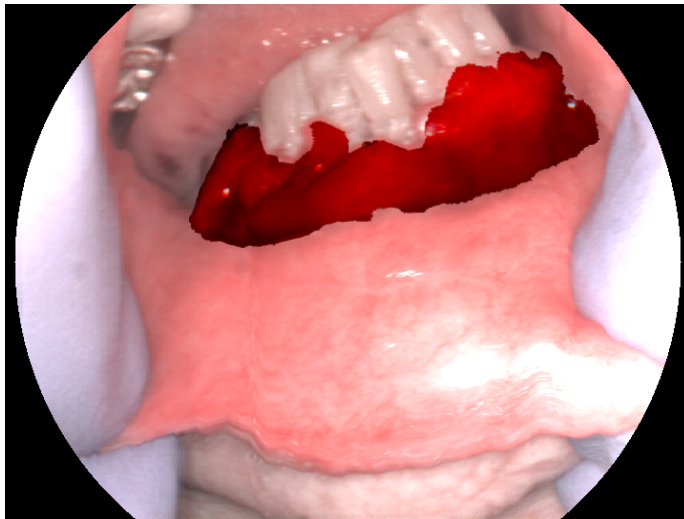
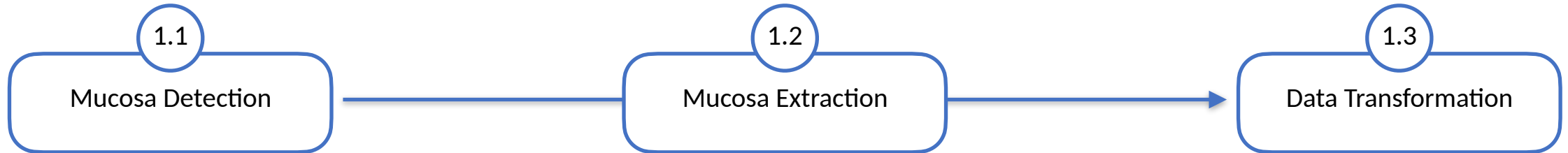


Train

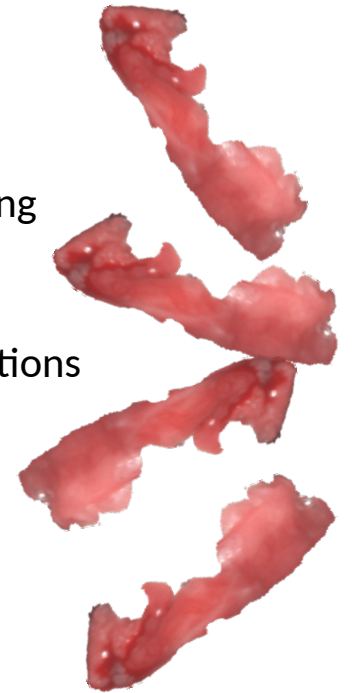


Our strategy

In-Vivo Oral Cavity Scan: Real world scenario



- Random cropping
- Flipping
- Rotation
- Elastic deformations



Our strategy

Tumor detection training on Ex-Vivo Frozen Section

2.1

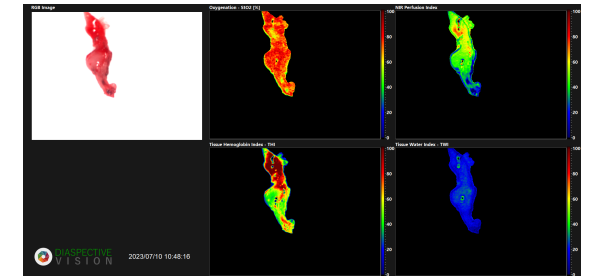
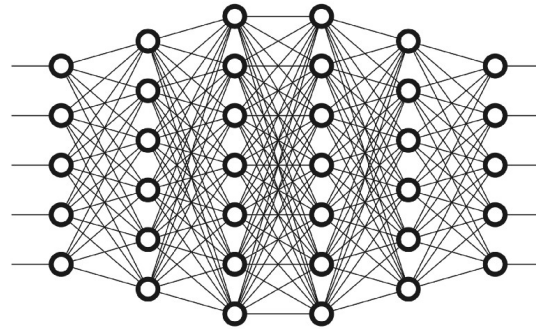
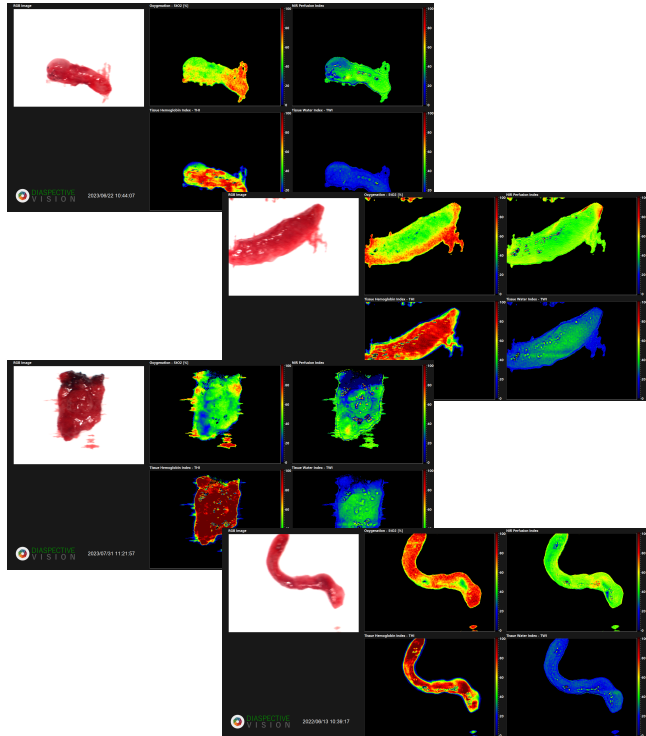
Annotated dataset for carcinoma

2.2

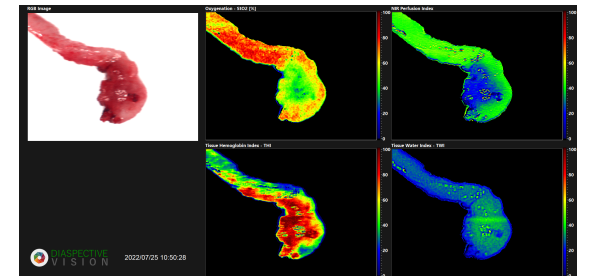
Train Deep Learning Model

2.3

Detection of carcinoma tumour



Free of carcinoma tumor



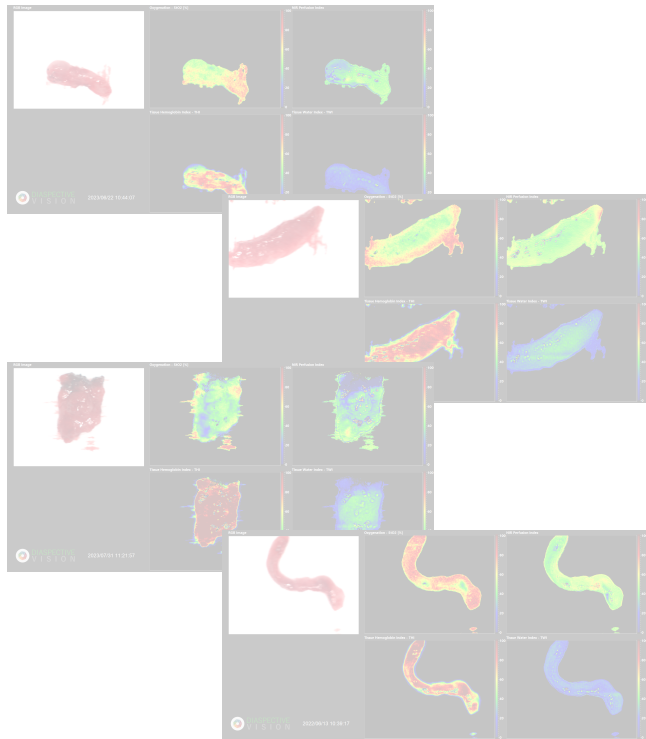
Carcinoma tumor detected

Our strategy

Tumor detection training on Ex-Vivo Frozen Section

2.1

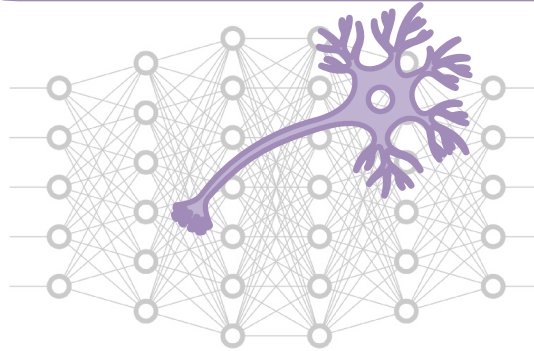
Annotated dataset for carcinoma



2.2

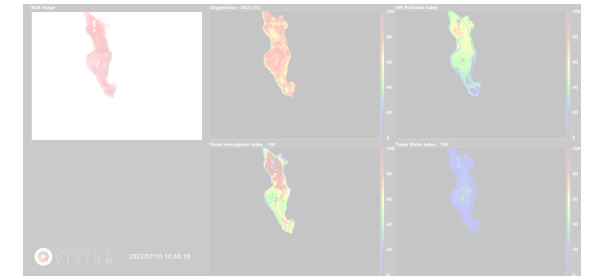
Train Deep Learning Model

DL model for Tumor Detection

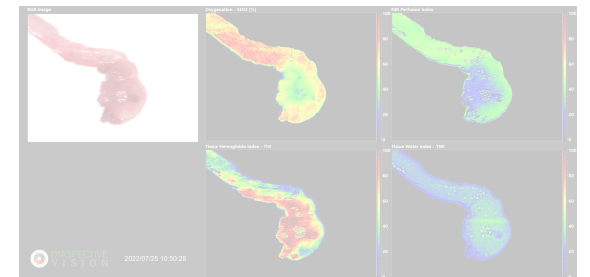


2.3

Detection of carcinoma tumour



Free of carcinoma tumor



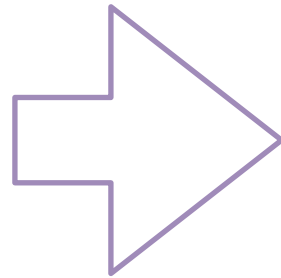
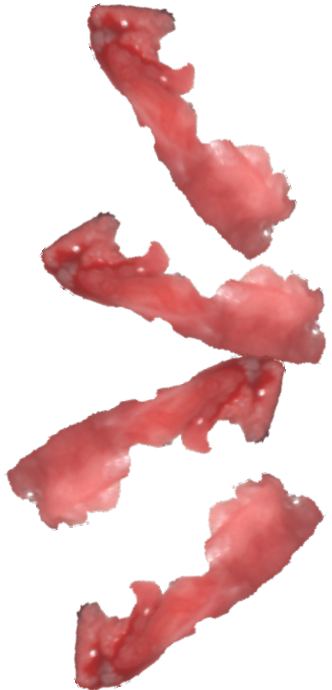
Carcinoma tumor detected

Our strategy

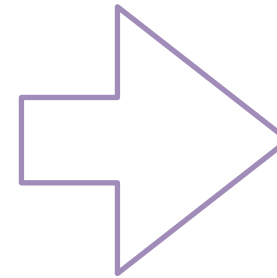
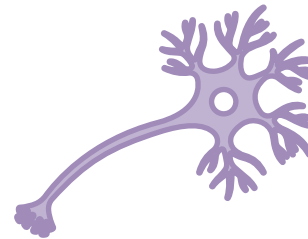
In-Vivo Oral Cavity Scan: Real world scenario

1.3

Data Transformation



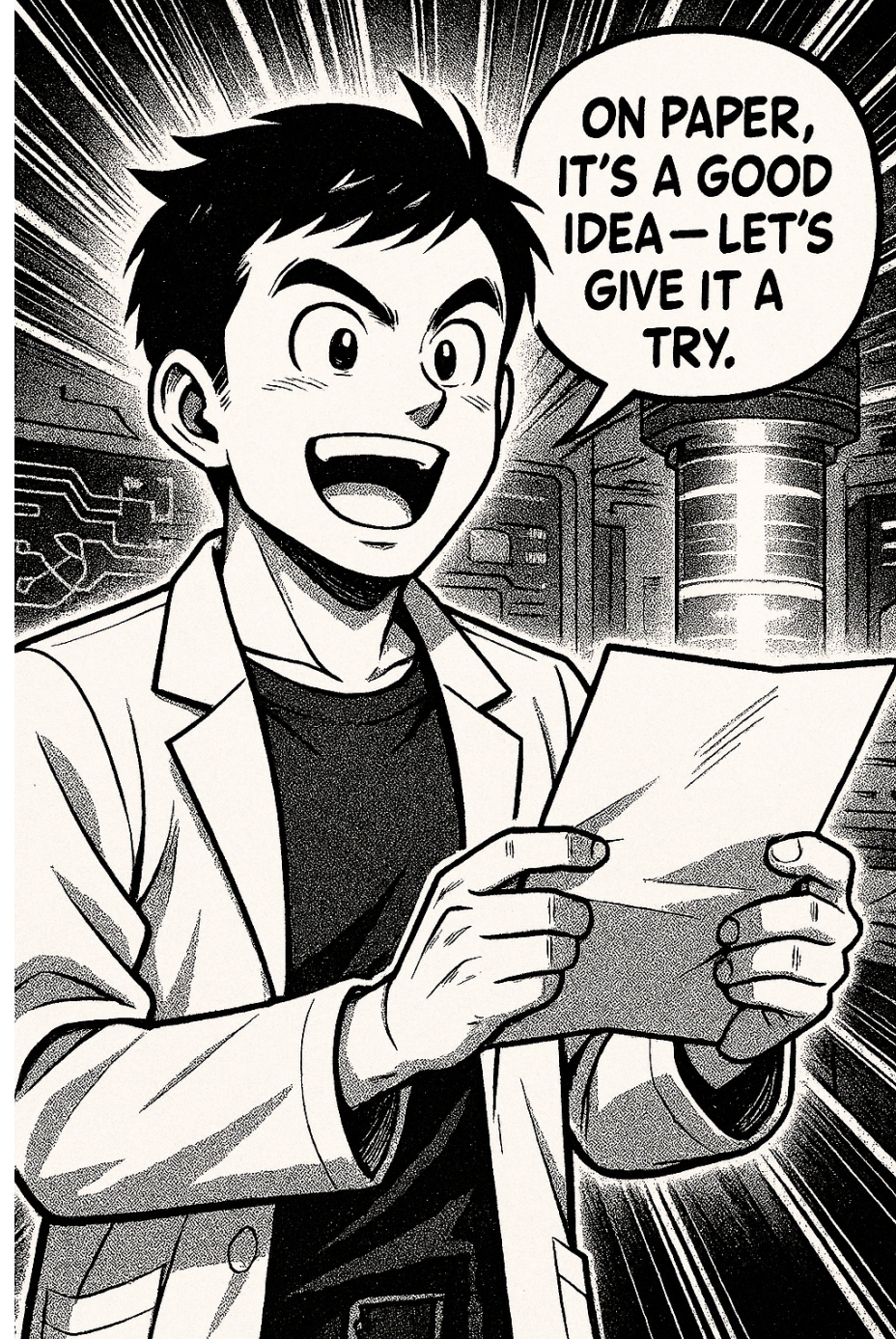
Deep Learning model for
Tumor Detection



3

Infer Tumor





1.1 Mucosa segmentation

1.1.1

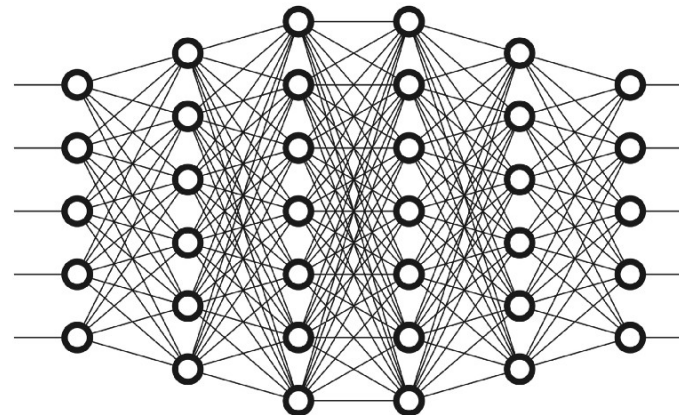
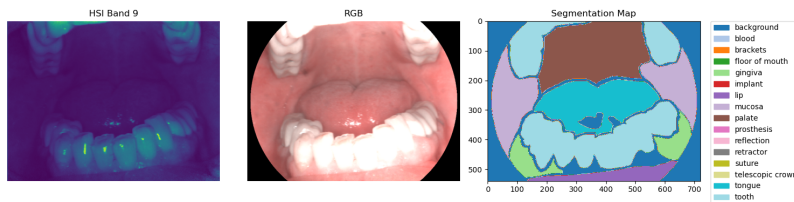
Annotated dataset

1.1.2

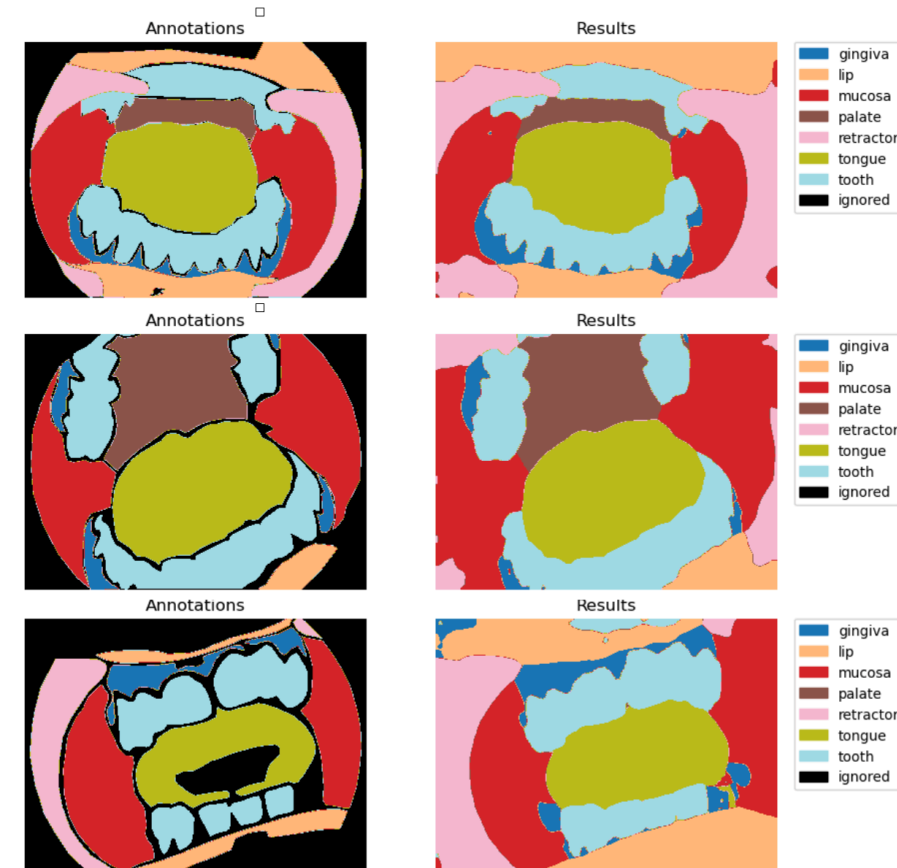
Train Deep Learning Model

1.1.3

Semantic Segmentation



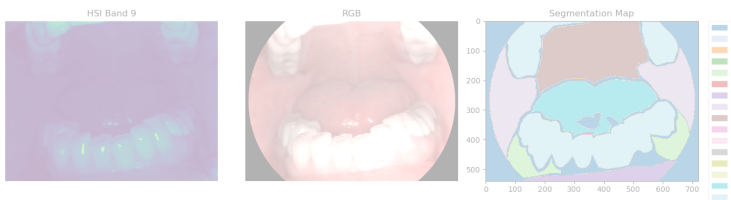
deeplabv3
 +
 resnet50 / resnet101



1.1 Mucosa segmentation

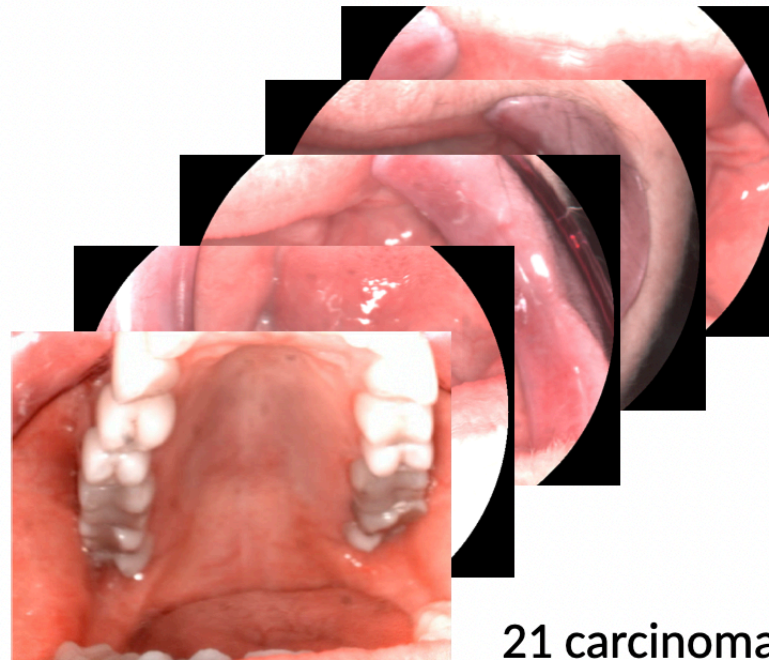
1.1.1

Annotated dataset



1

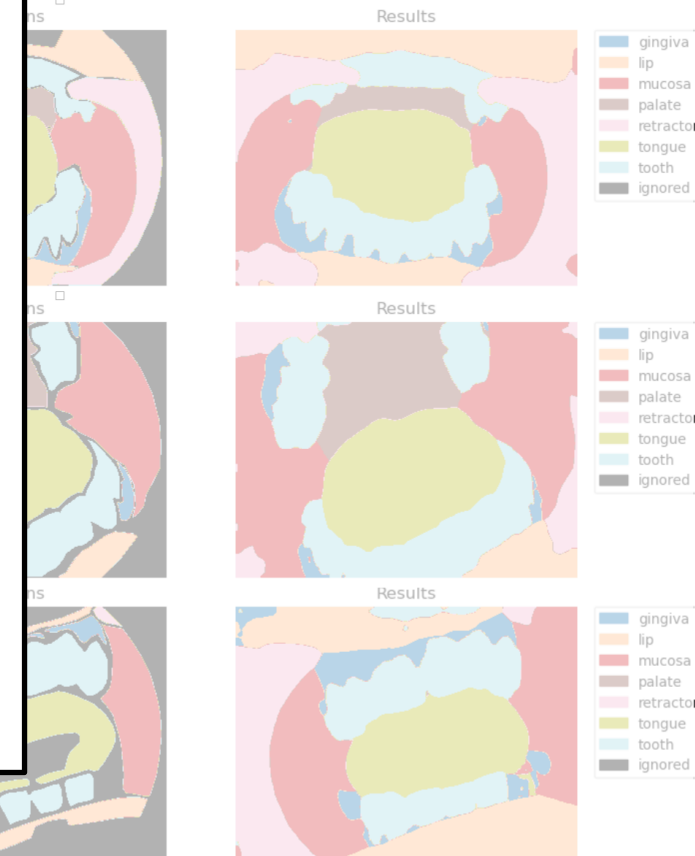
In-Vivo Oral Cavity Scan



21 carcinoma-positive
 752 non-carcinoma

1.1.3

Semantic Segmentation



1.1 Mucosa segmentation

1.1.1

Annotated dataset

1

In-Vivo Oral Cavity Scan

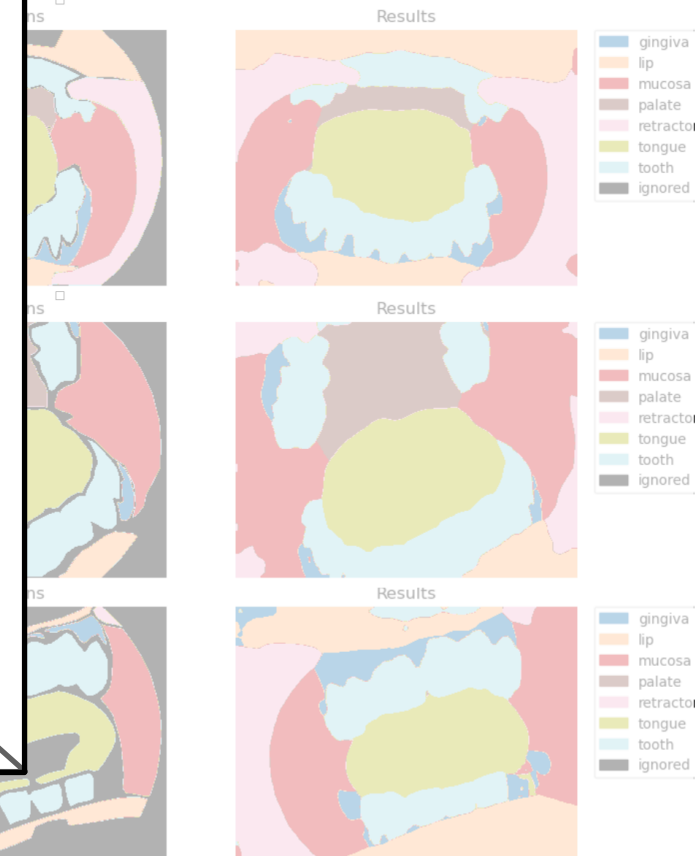
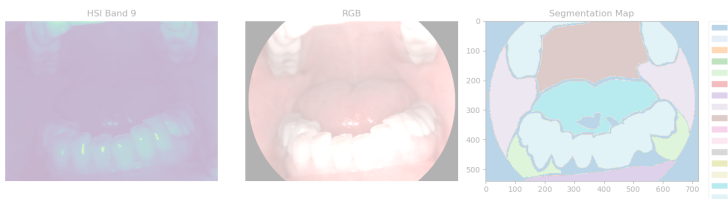
30% to infer

70% to train

21 carcinoma-positive
 752 non-carcinoma

1.1.3

Semantic Segmentation



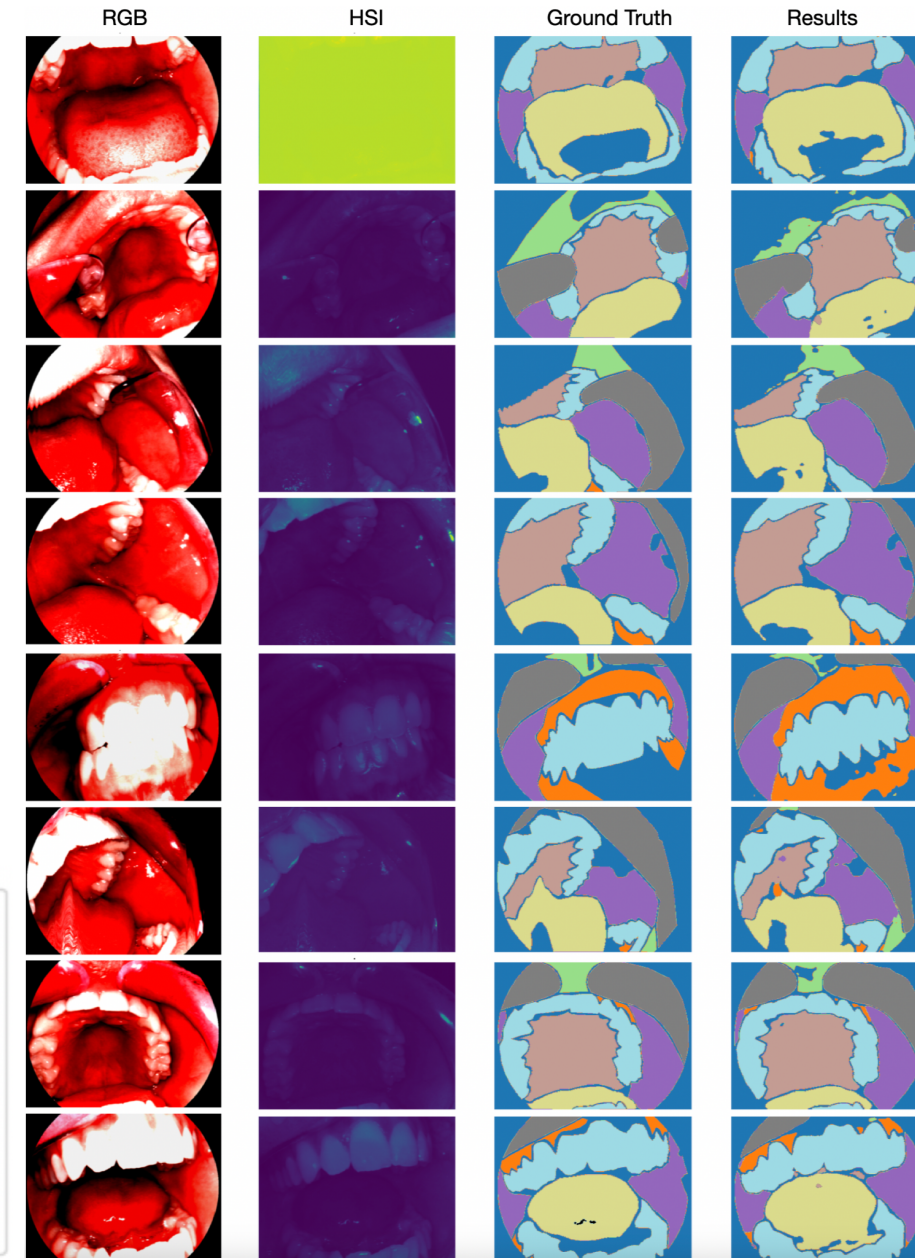
1.1 Mucosa segmentation

Results

DeepLabv3 ResNet-50 / DeepLabv3 ResNet-101

Model	Precision		Recall		F1 Score	
Overall	0.849	0.851	0.861	0.863	0.855	0.857
Palate	0.886	0.874	0.918	0.929	0.901	0.900
Retractor	0.936	0.942	0.940	0.938	0.938	0.940
Mucosa	0.915	0.914	0.914	0.916	0.914	0.915
Tongue	0.878	0.872	0.888	0.892	0.883	0.882
Clutter	0.840	0.844	0.848	0.849	0.844	0.846
Tooth	0.862	0.871	0.937	0.936	0.898	0.902
Lip	0.723	0.730	0.695	0.683	0.709	0.706
Gingiva	0.756	0.757	0.751	0.765	0.754	0.761

- clutter
- gingiva
- lip
- mucosa
- palate
- retractor
- tongue
- tooth
- ignored



2 Carcinoma Detection

2.1

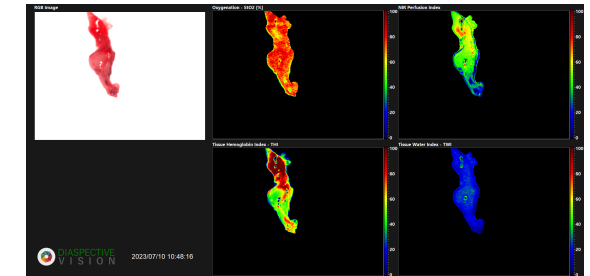
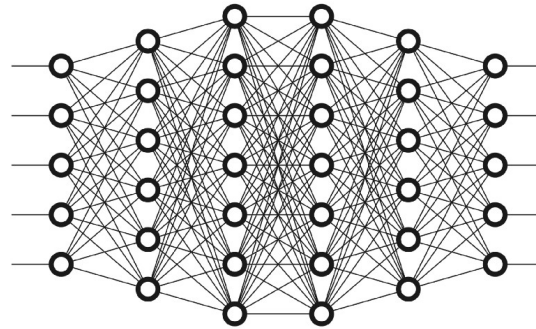
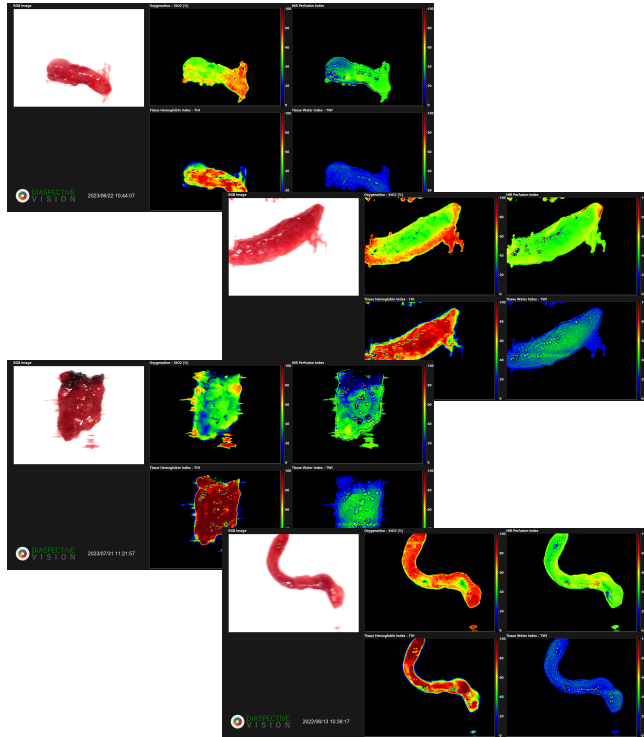
Annotated dataset for carcinoma

2.2

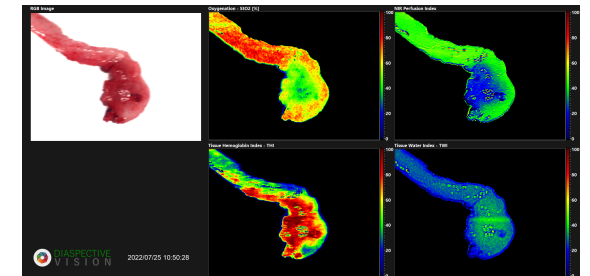
Train Deep Learning Model

2.3

Detection of carcinoma tumour



Free of carcinoma tumor

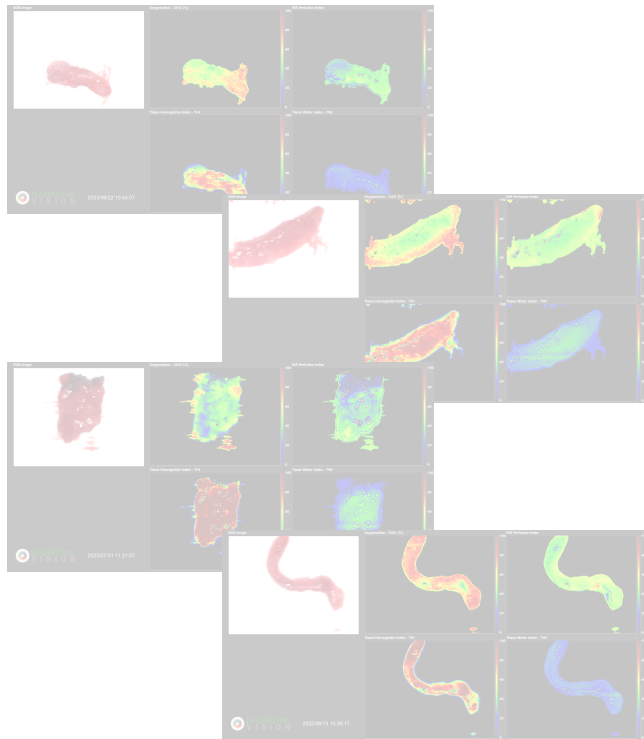


Carcinoma tumor detected

2 Carcinoma Detection

2.1

Annotated dataset for carcinoma



2.2

Train Deep Learning Model

Models trained and tested

- AlexNet
- ConvNeXt Base
- ConvNeXt Large
- ConvNeXt Small
- ConvNeXt Tiny
- ResNet18
- ResNet34
- ResNet50
- ResNet101
- ResNet152
- ResNeXt50-32x4d
- ResNeXt101-32x8d
- ResNeXt101-64x4d
- VGG11
- VGG11-BN
- VGG13
- VGG13-BN
- VGG16
- VGG16-BN
- VGG19
- VGG19-BN
- Wide ResNet50-2
- Wide ResNet101-2

2.3

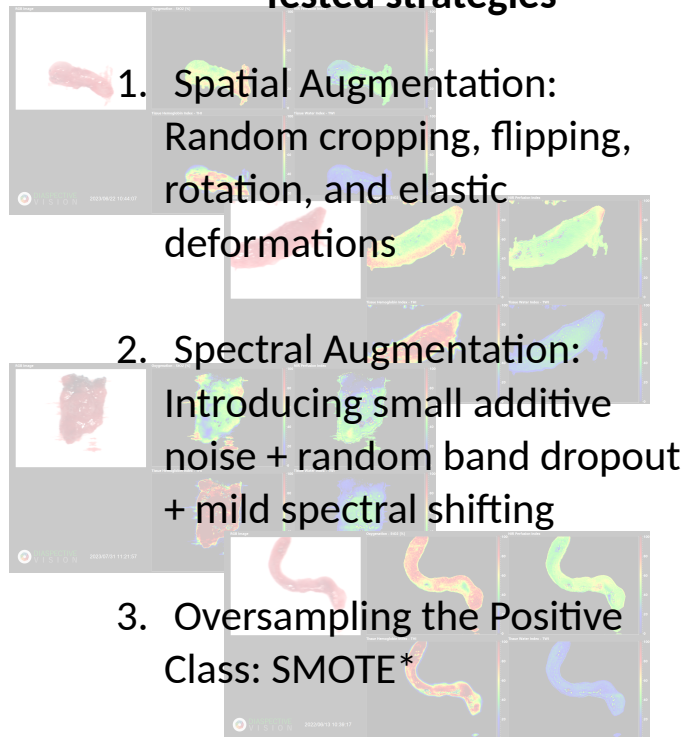
Detection of carcinoma tumour



2 Carcinoma Detection



Tested strategies



Models trained and tested

- 
- AlexNet
 - ConvNeXt Base
 - ConvNeXt Large
 - ConvNeXt Small
 - ConvNeXt Tiny
 - ResNet18
 - ResNet34
 - ResNet50
 - ResNet101
 - ResNet152
 - ResNeXt50-32x4d
 - ResNeXt101-32x8d
 - ResNeXt101-64x4d
 - VGG11
 - VGG11-BN
 - VGG13
 - VGG13-BN
 - VGG16
 - VGG16-BN
 - VGG19
 - VGG19-BN
 - Wide ResNet50-2
 - Wide ResNet101-2



2 Carcinoma Detection

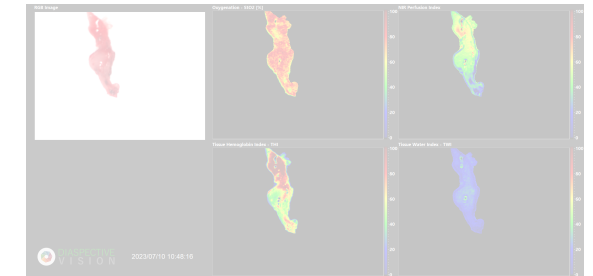


Hyperspectral 2D+1D CNN for Oral Carcinoma Detection

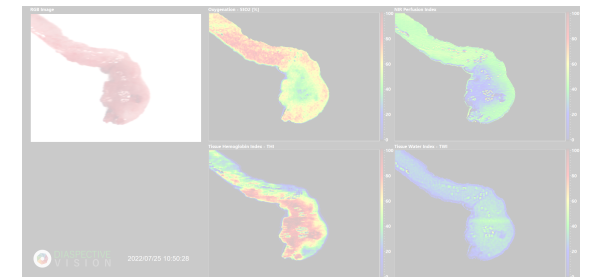
**BandEncoder
(2D CNN)**

**1D Convolution
Across Bands**

**Global Pooling
& Classification**



Free of carcinoma tumor



Carcinoma tumor detected

2 Carcinoma Detection

2.1

Annotated dataset for carcinoma

2.2

Build new model

Model

2.3

Detection of carcinoma tumour

Hyperspectral 2D+1D CNN for Oral Carcinoma Detection

This model combines **spatial** and **spectral analysis** for **hyperspectral imaging (HSI)** classification

Key Strength:

Leverages both **spatial structure** (within each band) and **spectral variation** (across bands) for **early small dataset**.

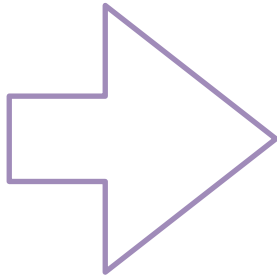
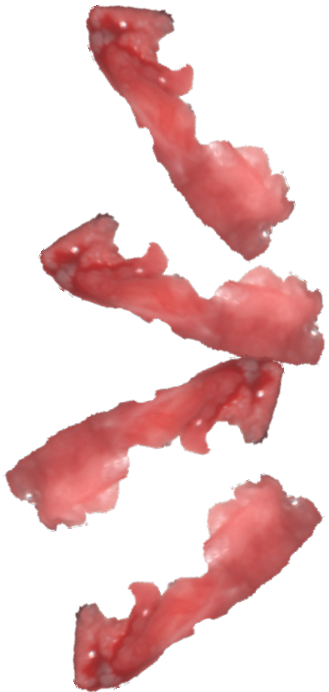


Detection of carcinoma tumor

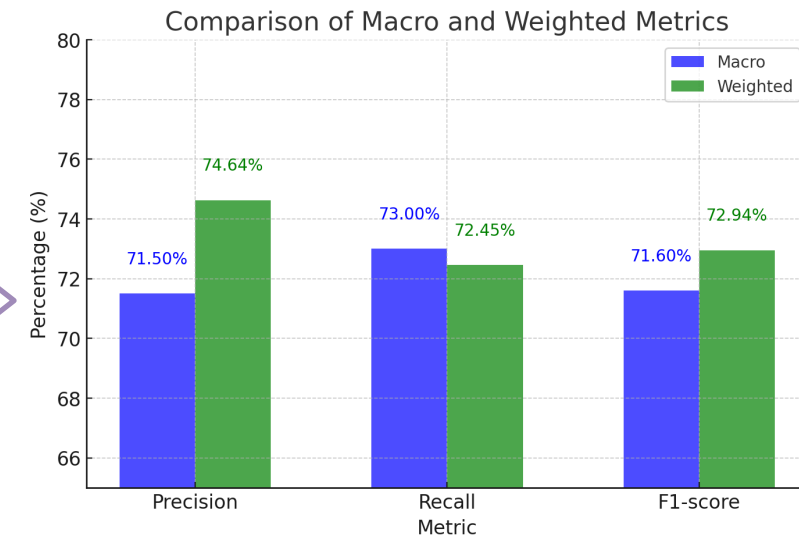
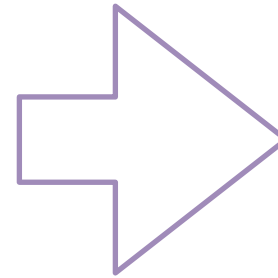
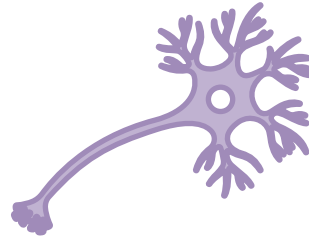
Results

2.3

Data Transformation



Deep Learning model for Tumor
Detection

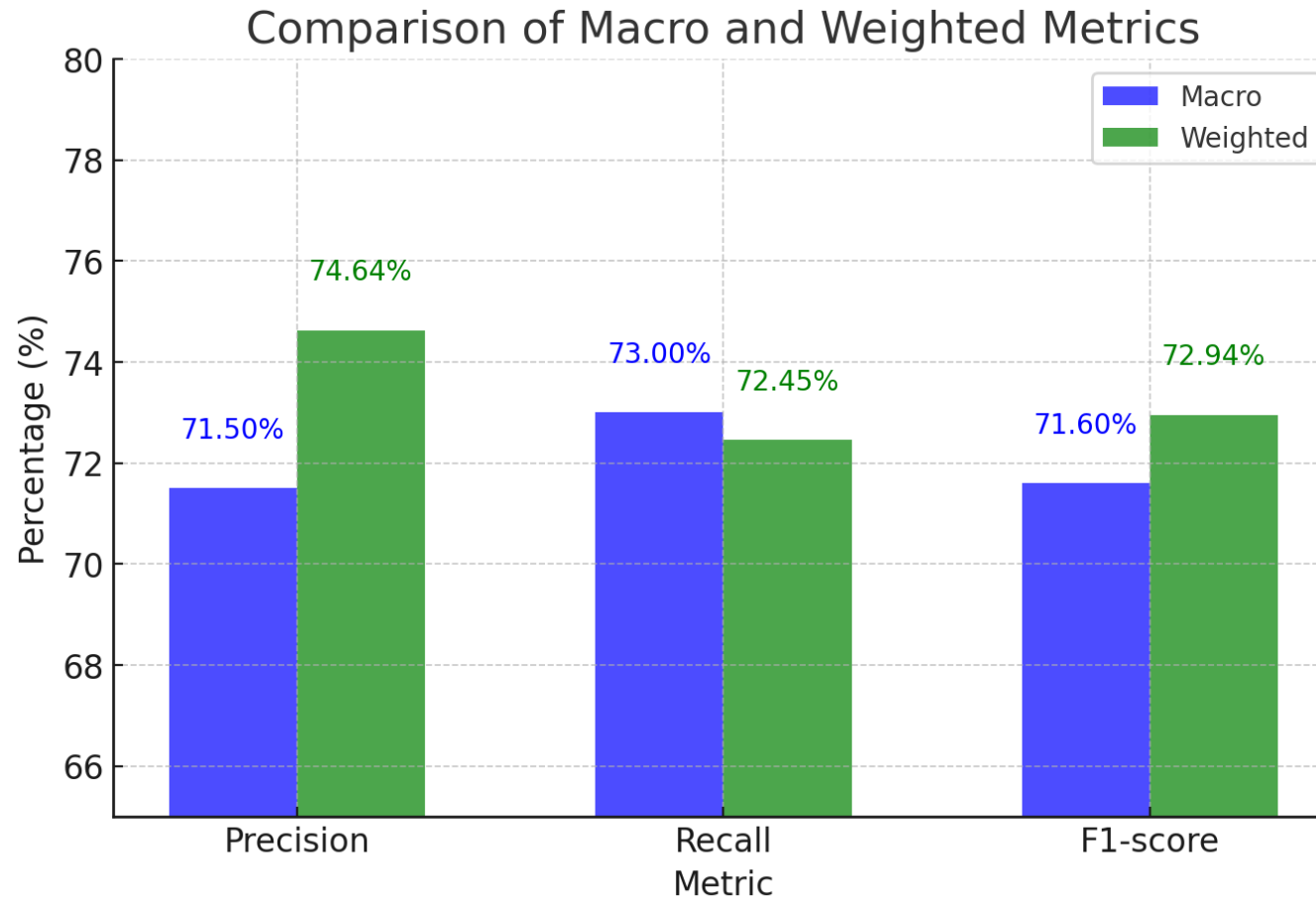


3. Detection of carcinoma tumor

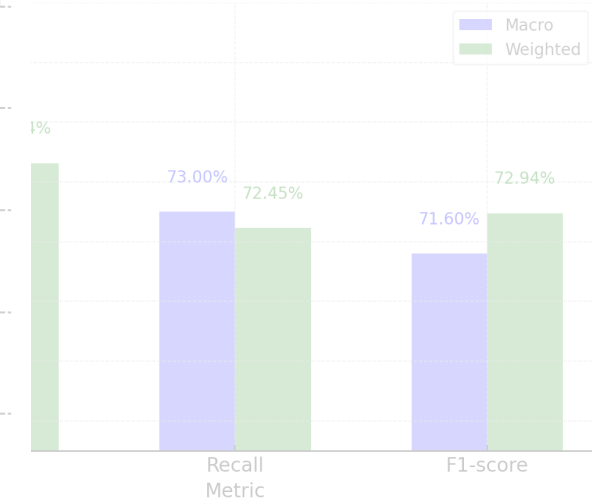
Results

2.3

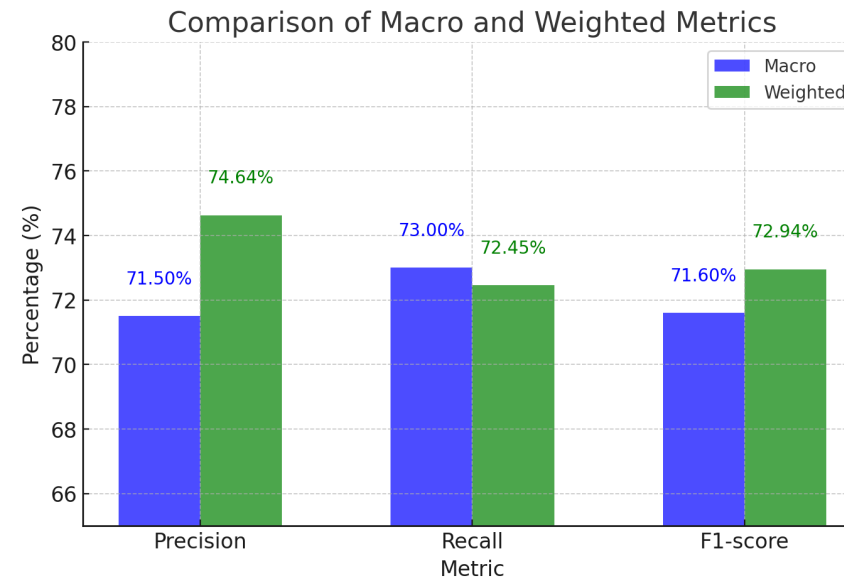
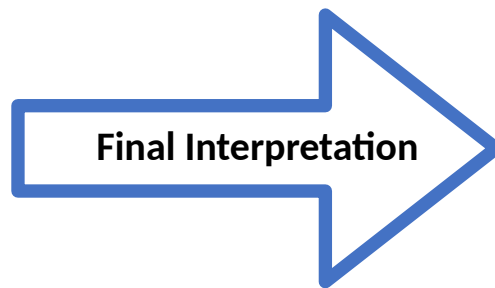
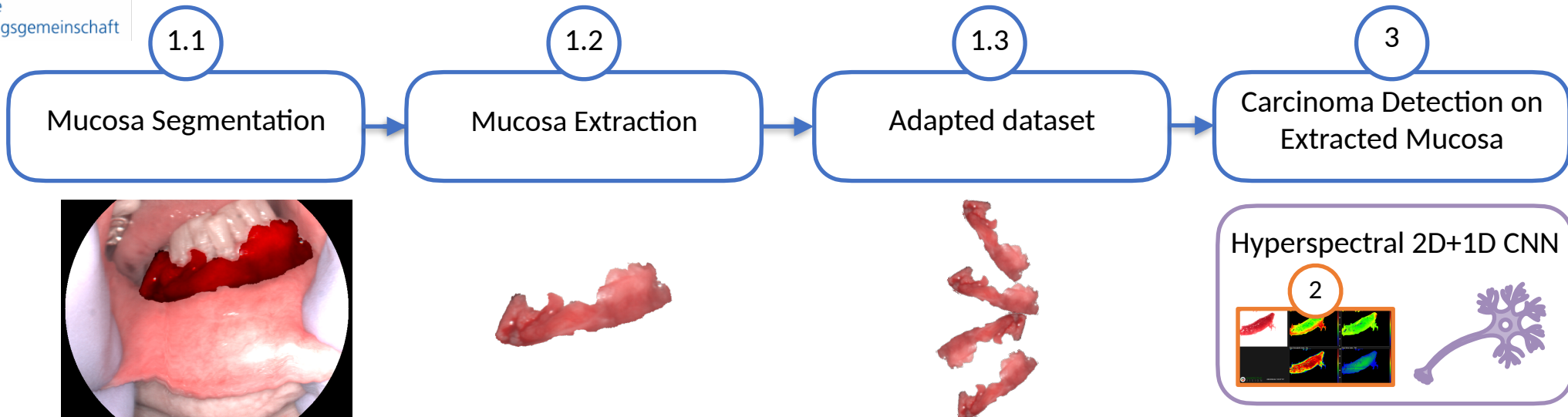
Data Transformation



Comparison of Macro and Weighted Metrics



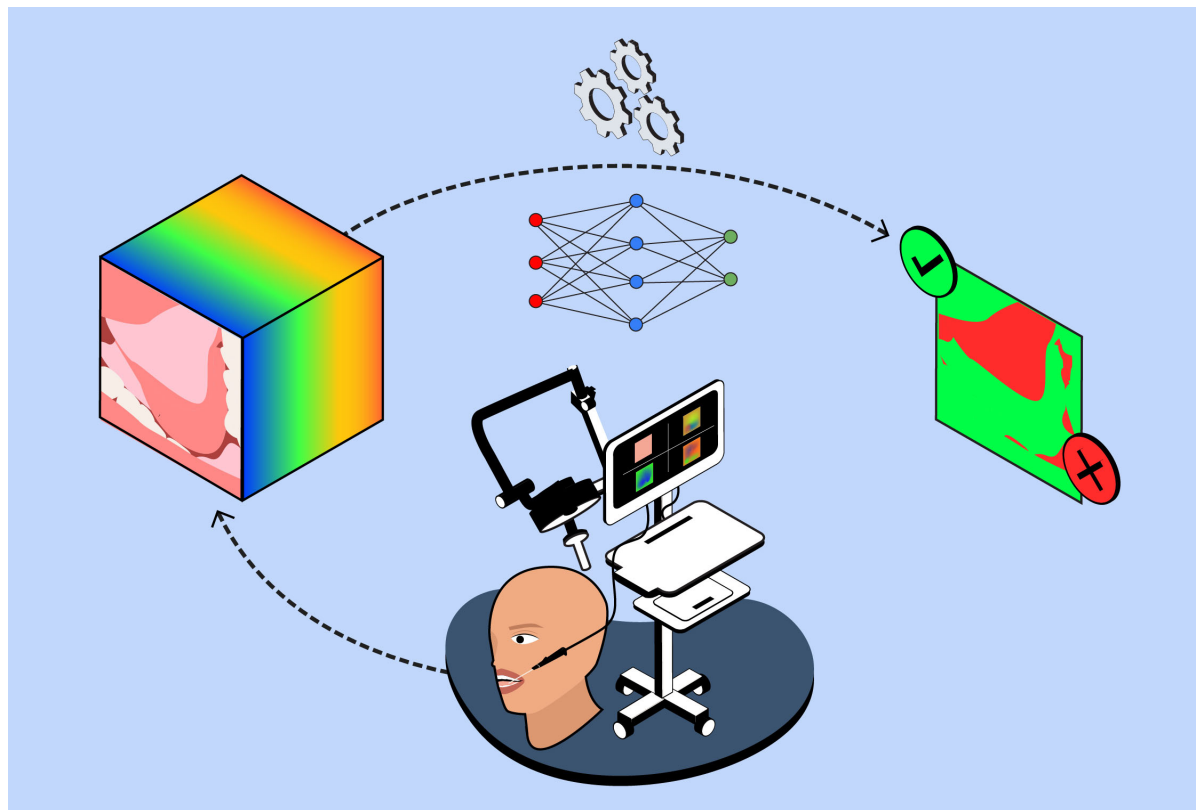
Conclusion



Enhancing Oral Diagnostics with Hyperspectral Imaging and Deep Learning



<https://i3mainz.hs-mainz.de/projekte/oralhype2-0/>



www.linkedin.com/in/jean-jacques-ponciano

Thank you

jean-jacques.ponciano@hs-mainz.de