Automatic Analysis of Fungal-Infected Tissue using Deep Learning

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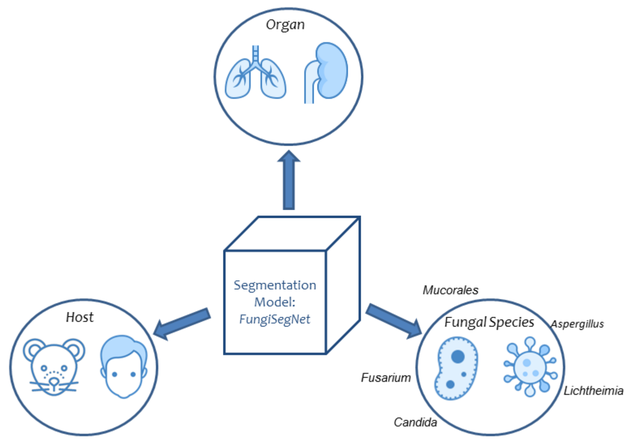
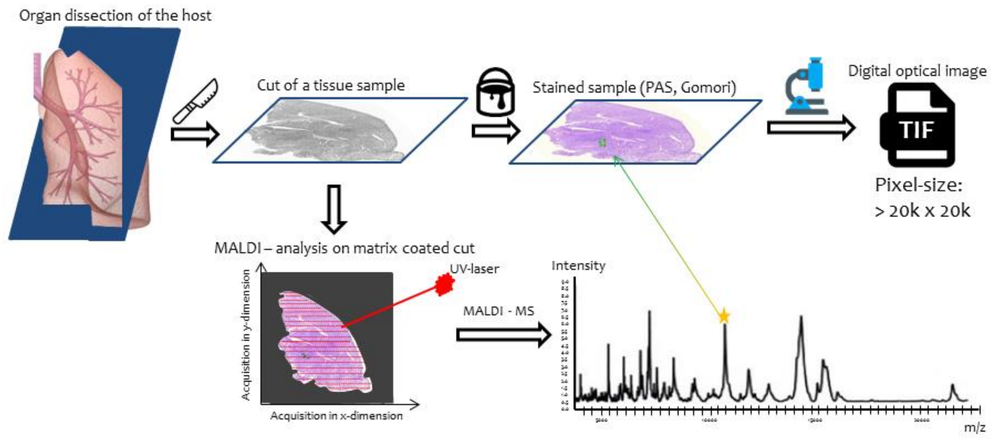
1. Experimental setup

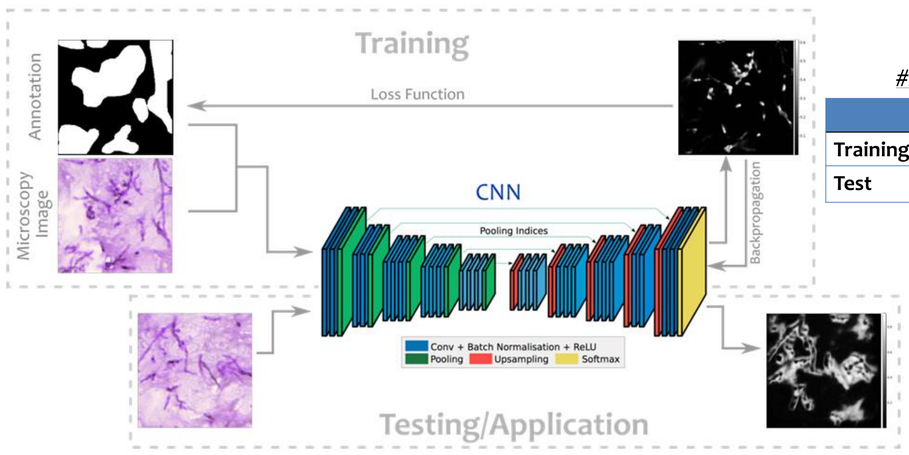
- **Combine optical image analysis with MALDI images to detect fungal infected regions**
- **Learn one model for each staining method:**
  - Gomori (Gömöri trichrome stain used on muscle tissue)
  - PAS (Periodic acid-Schiff reaction)
- **Classify mass spectrum (MS) according to respective fungus species**





2. Optical image segmentation

Deep Learning of Convolutional Neural Networks (CNN)

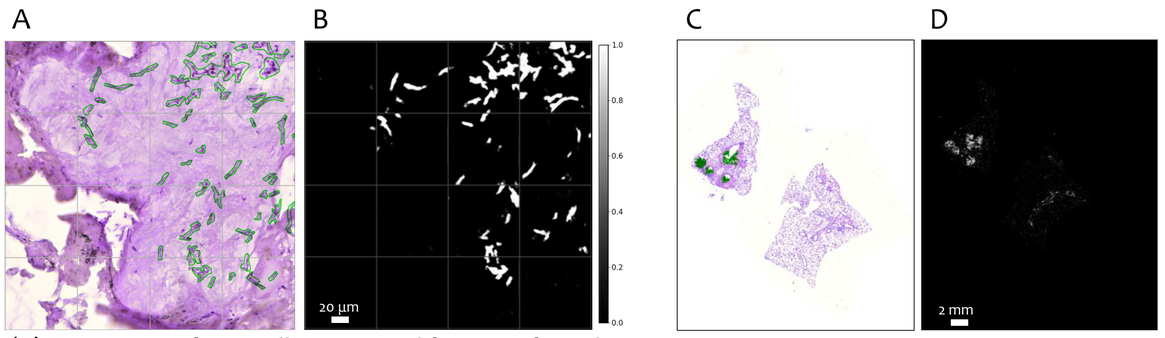


images

	Gomori	PAS
Training	2322	2850
Test	410	503

- Network – metric-value on test images: $Dice\ Coefficient(DC) = \frac{2x\ TP}{2\ TP+FP+FN} = 1.0$
- Network – loss-value on test images: $L(y, \tilde{y}) = \sum_{j=0}^{\infty}\sum_{i=0}^{\infty}(y_{ij} * log(\tilde{y}_{ij})) + DC = 0.3067$

Segmentation results **Network inference**

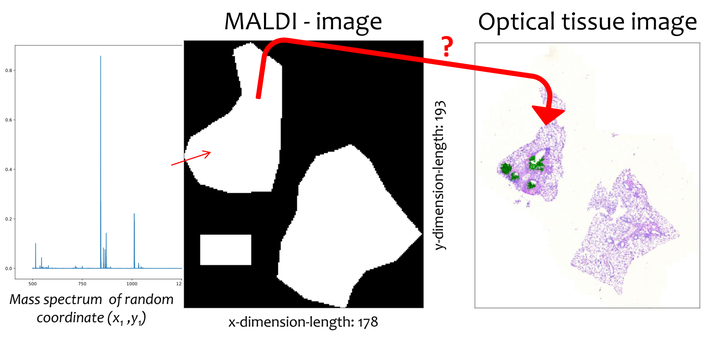


(A) Test region of manually annotated fungus-infected tissue
(B) Network prediction: white regions correspond to high probability *P* of fungal-infected tissue Scalebar: *P(fungal-infected tissue)*
(C) Complete tissue sample: green regions represent the annotated fungus
(D) Network inference for the entire sample image

3. Interface for optical image – MALDI image

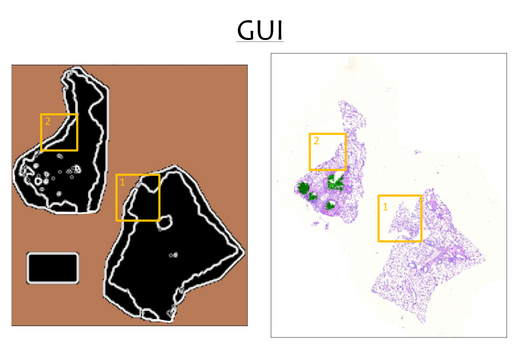
Issue:
- We need to correlate MS coordinates with the corresponding position in the optical tissue image
- No free or commercial software solution existing

Approach:
- Approximate assignment of each MS to the original tissue image
- Use of an interactive graphical user interface (GUI)



Perform clustering with two classes to distinguish between background and tissue

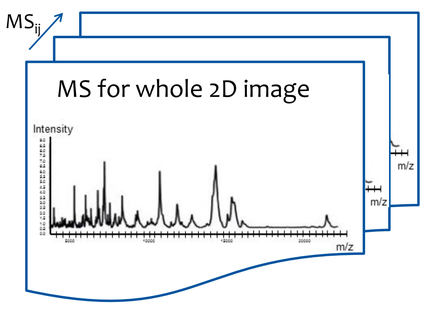
Selection of fixed points, which will be used as anchor points for co-localization



4. Classification of MALDI-imaging

- MALDI image is 2D image with 50 µm resolution (e.g. 190 x 170 MS)
- Each MS contains values for m/z (mass-to-charge ratio)
- Each value represents an intensity

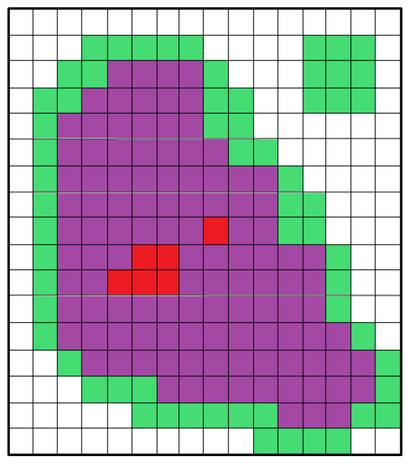
Sample MS:
- $Dimensionality\ per\ MS = 8000$



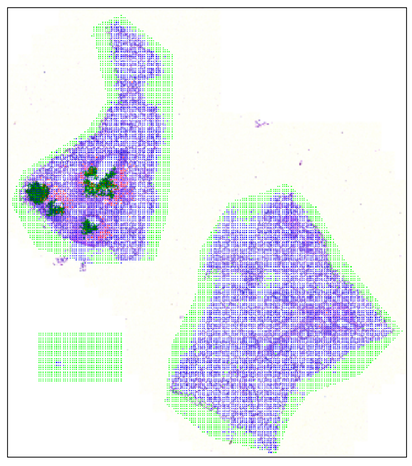
Dimension reduction by Autoencoder

Vector with 16 features for each MS

Classify each MS with Random forest classifier by using probability-map as label



Preliminary result



- Overlay of stained tissue and MALDI image
- Light Green: Background
- Dark Green: Annotated fungal infected tissue on stained images
- Purple: Tissue
- Red: MS classified with fungus

5. Conclusions

- Deep learning of neural networks allows to identify fungal-infected tissue
- Novel approach for the registration of optical tissue image and MALDI image
- Machine learning models allow to associate fungal-infected tissue with MS-spectra

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Pathogenic fungi and their human host: Networks of interaction
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