DETECTION OF CANCEROUS TISSUE IN FULL FIELD OCT IMAGES USING CONVOLUTIONAL NEURAL NETWORKS

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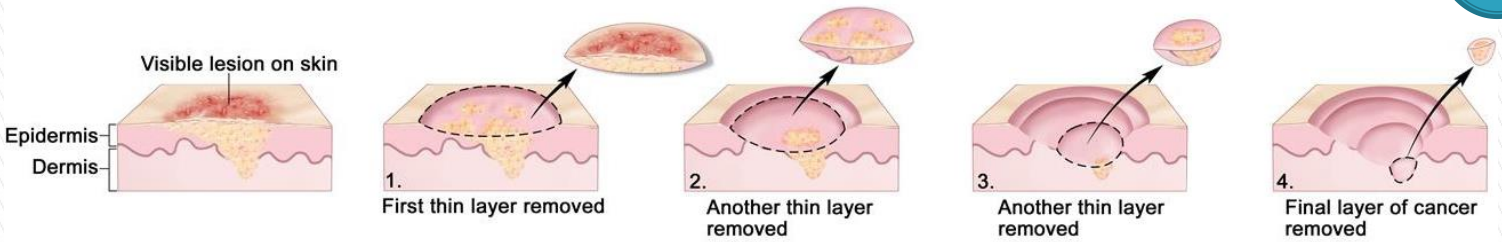
CONTEXT Mohs Surgery

- Golden standard for treating **non-melanoma skin cancer**
  - most common cancer: **3,5 million** cases / year in the U.S.
  - Basal Cell Carcinoma 80%
  - Squamous Cell Carcinoma 20%
- **Excisions** followed by microscope **examinations**
- Tissue fixed, frozen, sliced, stained, imaged
- Examinations take 2-3 hrs per surgery

speed up



CONTEXT Full Field Optical Coherence Tomography

- Optical biopsy – tissue reflectivity
- Non-invasive: no tissue preparation
- *En face* imaging
  (compared to cross-sectional OCT)
- Intracellular resolution: **1µm in 3D**
- Dermis penetration depth: **~200µm**
- Fast: **5min/cm²**
- Pathologists not familiar

make widely available

Light-CT Scanner
by LLtech

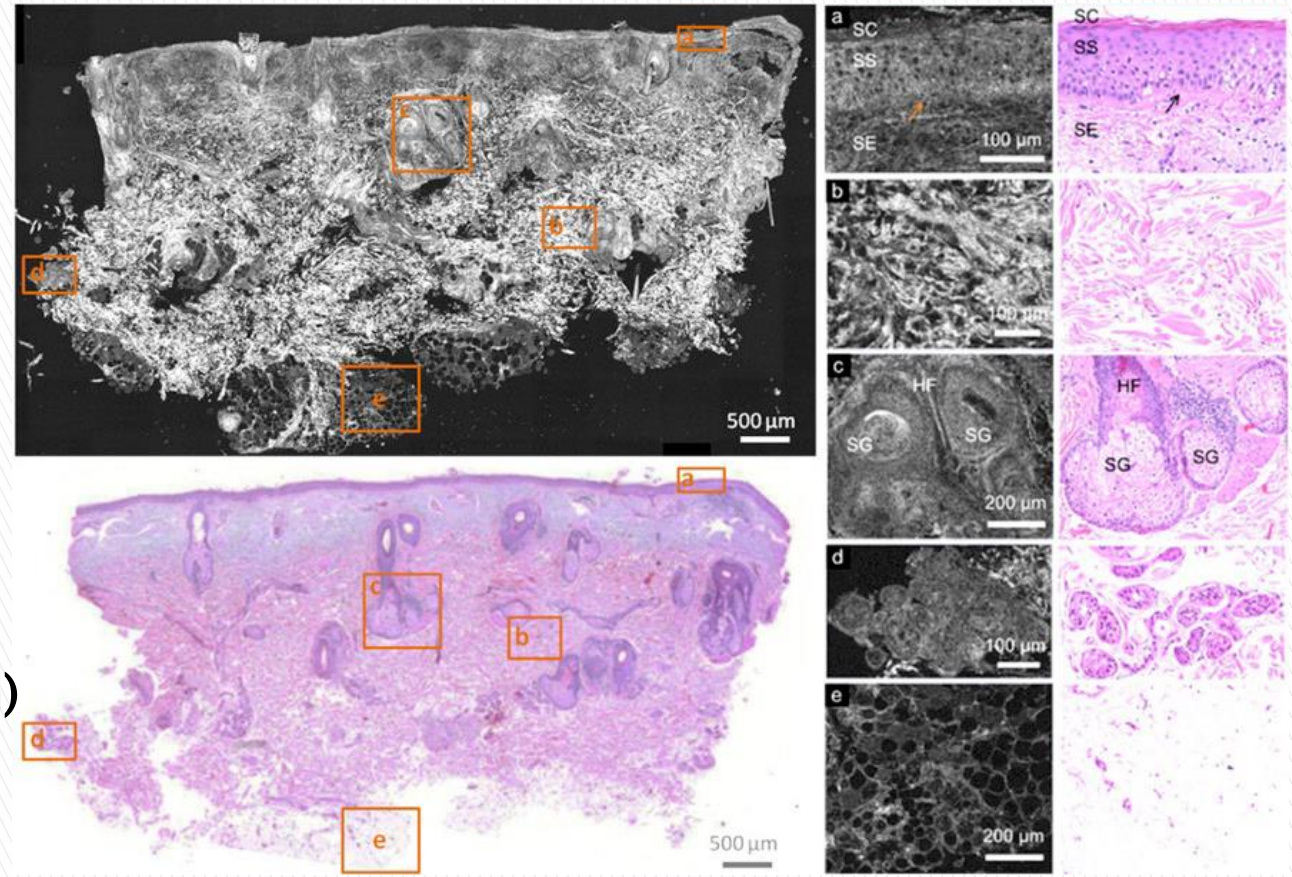
CONTEXT Full Field Optical Coherence Tomography

FFOCT

vs.

Histology

(Normal skin)



Epidermis

Collagen

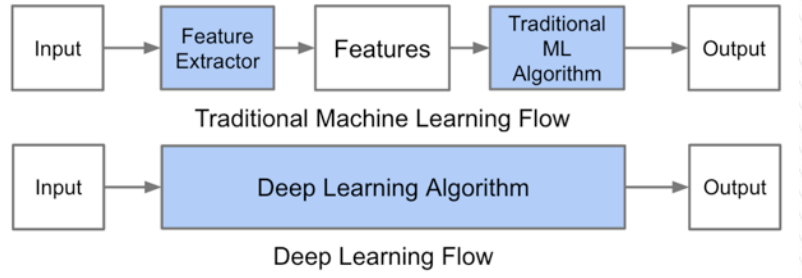
Hair Follicle
+
Sebaceous Glands

Sweat Gland

Adipocytes

CONTEXT Deep Learning

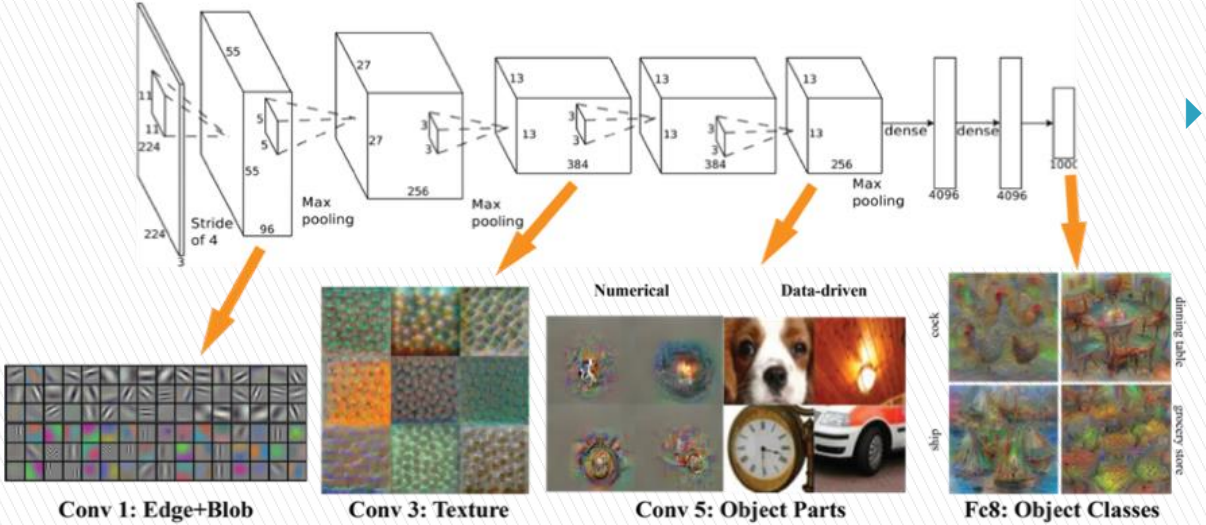
- State of the art in: object recognition, image captioning, handwriting detection
- Machine learning: feature engineering
- Deep learning: features *learned* from data



- Neural networks: interconnected layers of neurons

CONTEXT Convolutional Neural Networks

- Convolution:
  - filter – feature
  - activation map – response of image to filter
- Pooling:
  - dimensionality reduction
  - invariant to small transformations



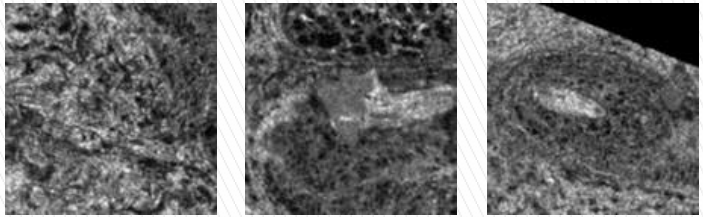
- Hierarchical representation

"ImageNet Classification with Deep Convolutional Neural Networks", Alex Krizhevsky et al.

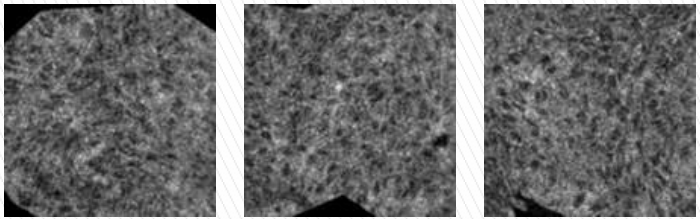
APPLICATION Data

- 10 annotated images, 3 with BCC

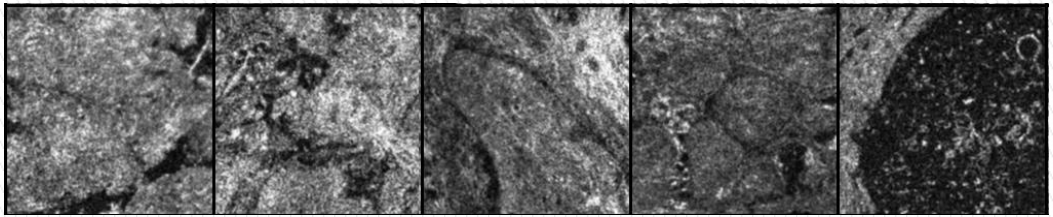
Normal:
- high variation
- multiple structures
- 93,8% of dataset



BCC:
- homogenous
- high density of nuclei
- 6.2% of dataset



- 40 annotated images, 10 with BCC



Infiltrative BCC:
- abnormal appearance
- collagen too reflective, covers nuclei

APPLICATION Data Sampling

- Class imbalance problem
- Oversample minority class
- Patches (200x200px):
  - **Normal** :

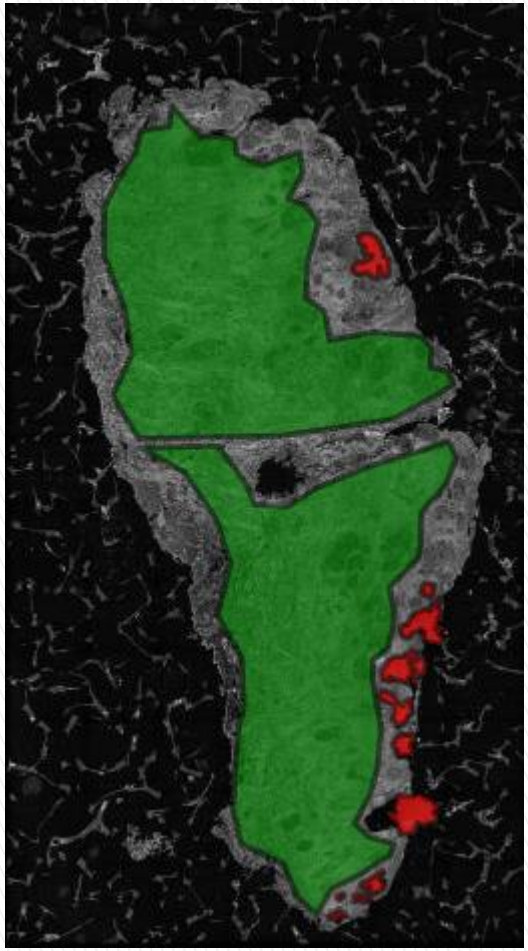
    10.641 distinct

    Context: 80% labeled
  - **BCC** :

    98 distinct

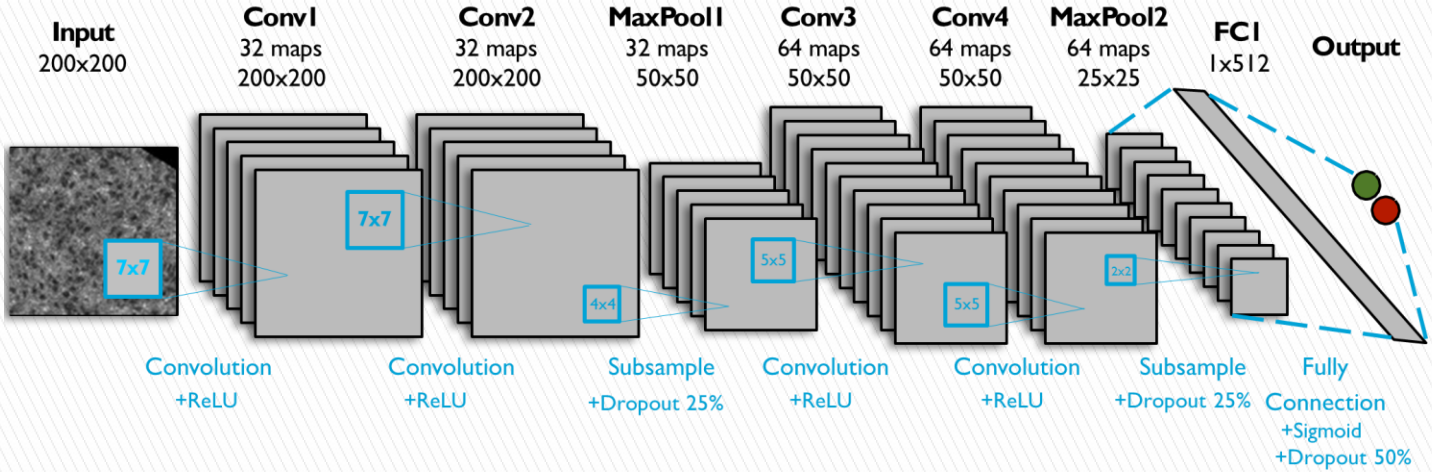
    9.741 overlapping (stride:20px)

    Context: 30% labeled (surrounded by unlabeled abnormal tissue)



APPLICATION Supervised Approach

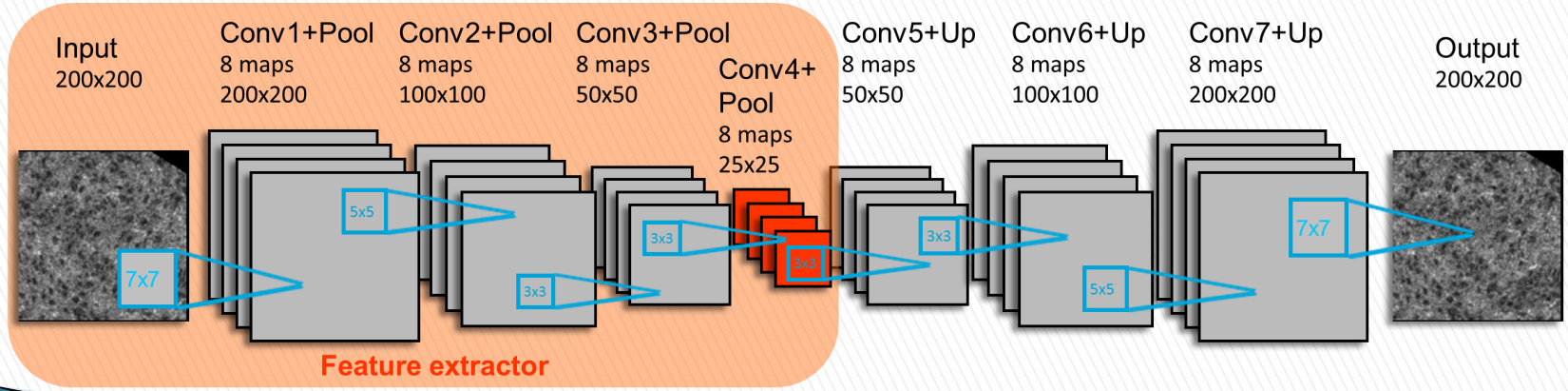
- *LeNet:*
  - depth
  - layers
- *AlexNet* :
  - conv block
  - dropout
  - ReLU



	Trained + Tested on 10 images	Trained on 10 imgs Tested on 40 imgs	Trained+Tested on 40 images
Specificity	89,62%	93,22%	79,48%
Sensitivity	99,94%	35,40%	93,22%
Accuracy	94,60%	91,74%	84,92%

APPLICATION Unsupervised Approach

- Convolutional auto-encoder
  - encoder
  - **features**
  - decoder



APPLICATION Unsupervised Approach

- Remove decoder and add classifier
- **Classifier**: SVM, Random Forest, Fully Connected neuron

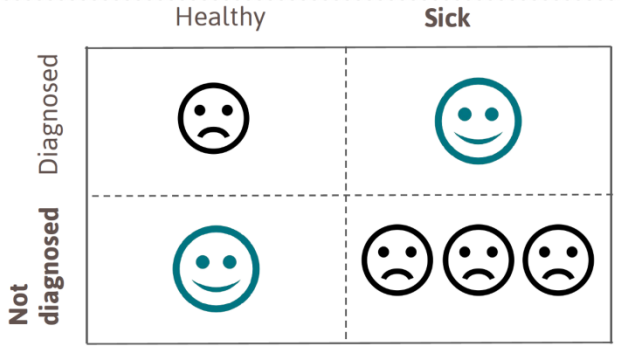
	Random Forest 500 trees	Fully Connected 1024 + 256 neurons
Specificity	55,28%	74,54%
Sensitivity	90,38%	97,75%
Accuracy	73,66%	86,69%

APPLICATION Performance

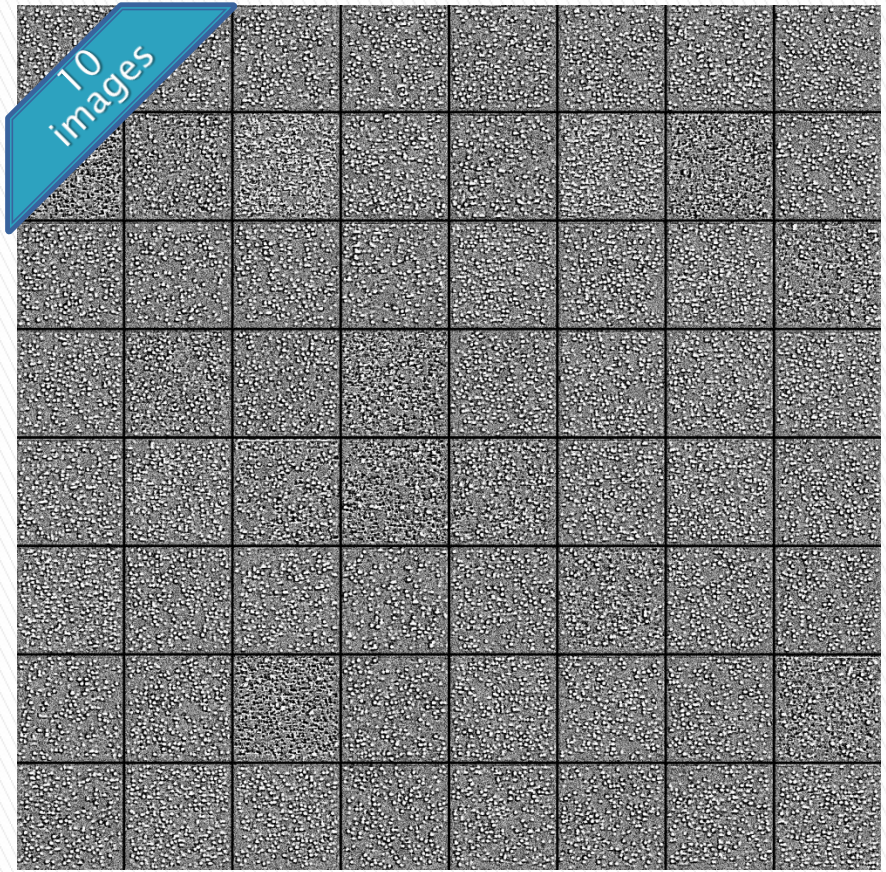
- Choose performance measure according to problem statement and data:

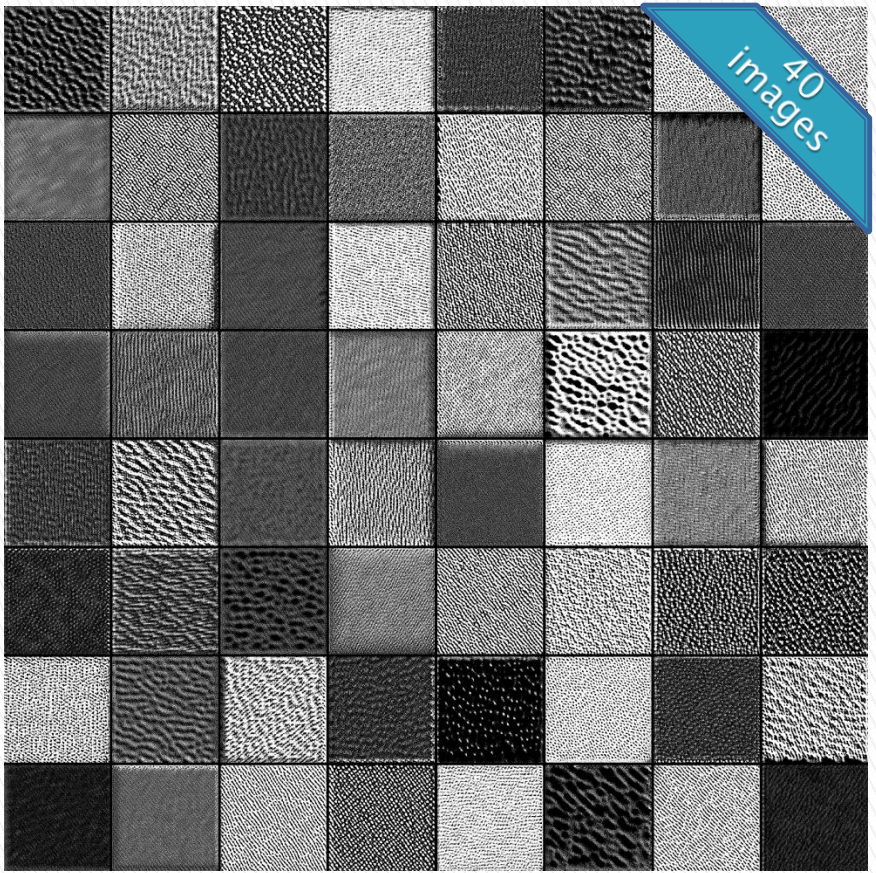
  sensitivity > specificity

- Understand **black-box** model
- **Visualize** to understand:
  - Filters
  - Activation maps
  - Maximum activation input



APPLICATION Network Visualization (activation maximizing inputs)



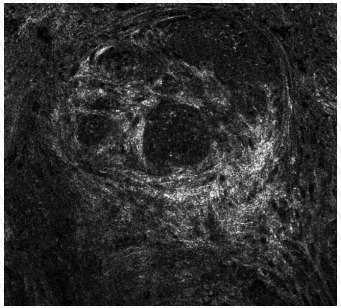


CONCLUSION

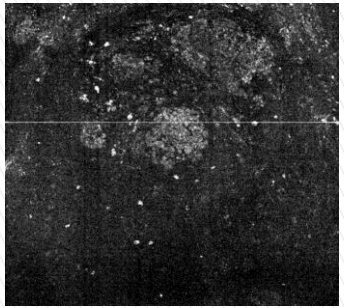
- Real world problem
- Computer-aided diagnosis
- Novelty imaging technique: FFOCT
- Modern, expanding computational paradigm: DL
- Understanding black-box model: Visualize Network

FUTURE WORK

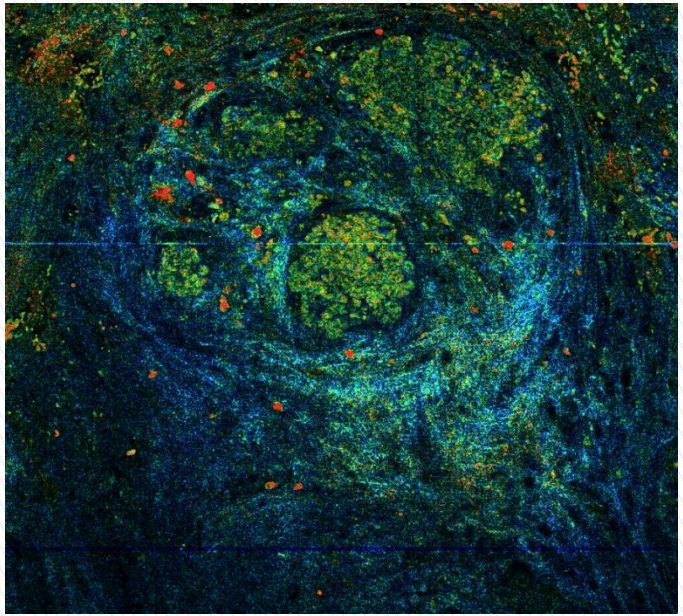
- Segmentation
- Histological appearance
- Dynamic FFOCT
  - metabolic index
  - cell velocity
- Multi-modal
  - add clinical data



FFOCT



Metabolic index map



D-FFOCT combined images
(mouse intestinal tumor)

REFERENCES

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