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Deep Learning in medical applications

BMDLab - Biomedical Data Analysis Lab
www.ux.uis.no/bmdlab

NORA kick-off, 01.04.19

Deep learning in medical applications

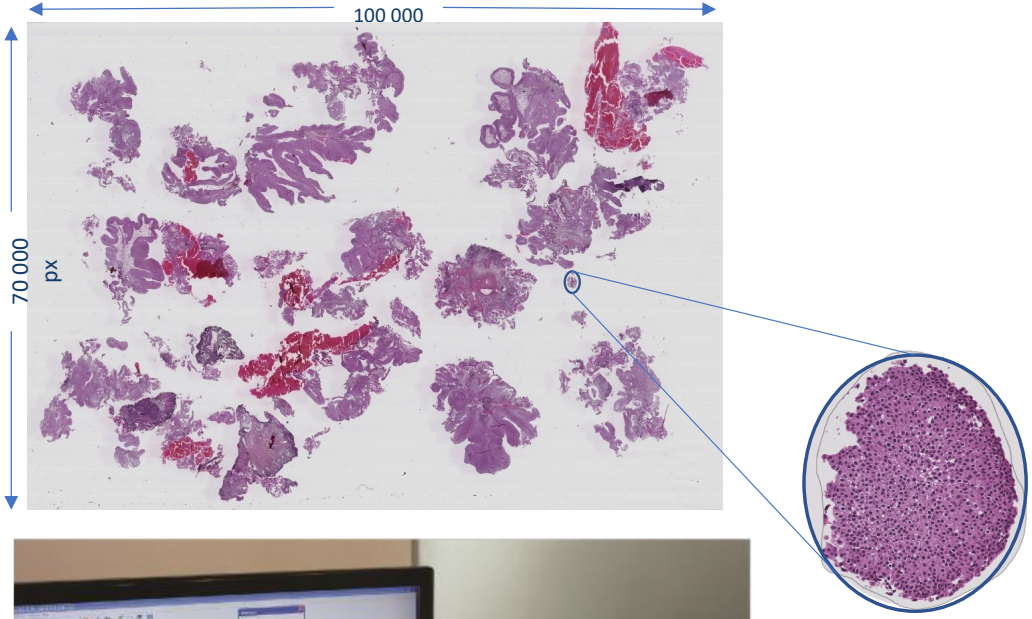
Deep neural networks and deep learning – Impressive success in later years all thorugh the worlds of computer vision, image processing, signal processing, computer science etc.

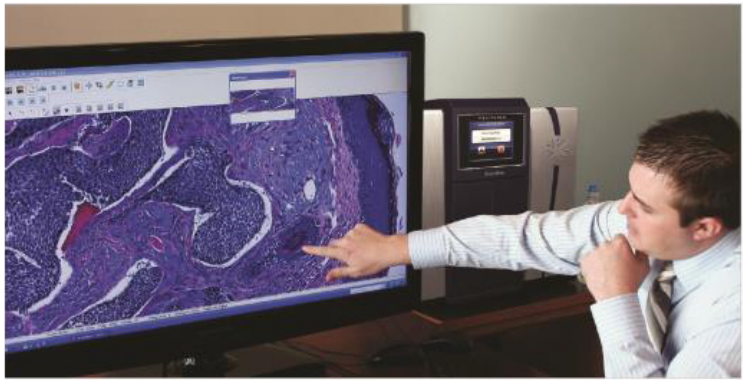
Challenges with data access in medical applications.
Combining domain knowledge and data learning!

This short talk will focus on two medical applications:

histopathological images, and safer births

Automated analysis of histopathological images of unrinary bladder cancer





- Digital pathology: scanned whole slide images (WSI) opens new possibilities
- Norway in a unique position to exploit this since first country digitizing all pathology labs, collecting all WSI in a centralized database
- Automated analysis for:
  - Time efficient, objective, reproducible interpretation
  - Region of interest extraction for further analyses and/or visualization
  - Segmentation of cancer areas, and classification of cancer grade and diagnoses
  - Prediction of recurrence and progression risks

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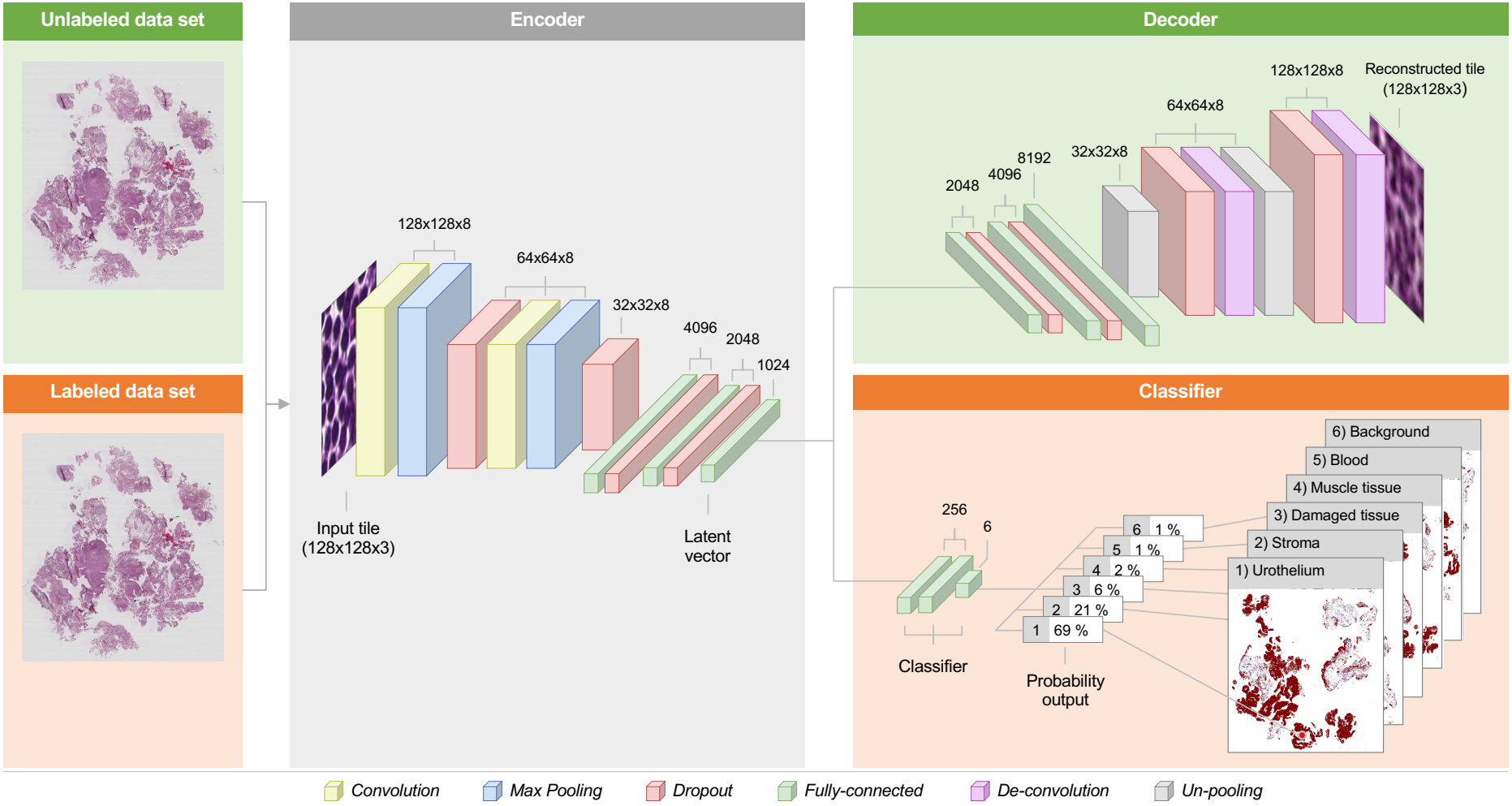
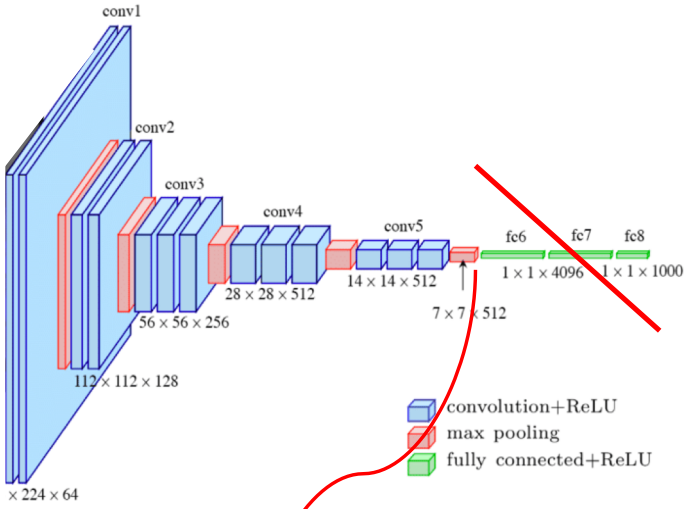
ROI extraction / segmentation 1:

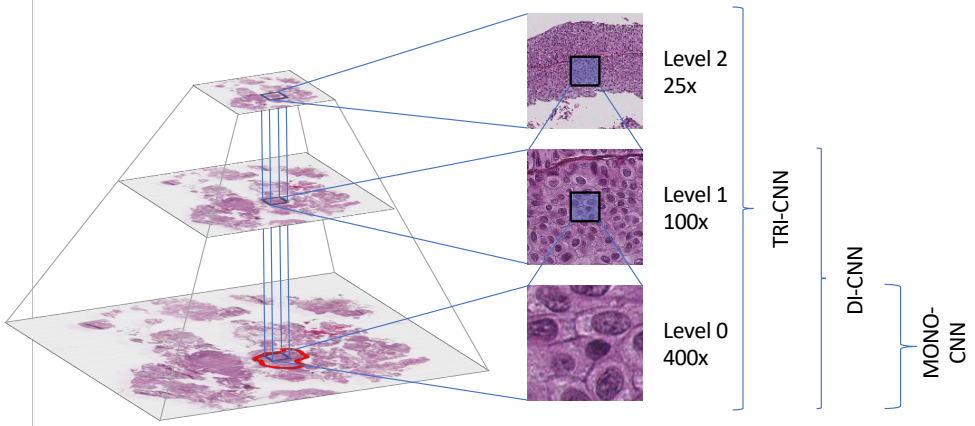
Learning relatively small networks from scratch on few and sparsly labelled data utilizing autoencoders

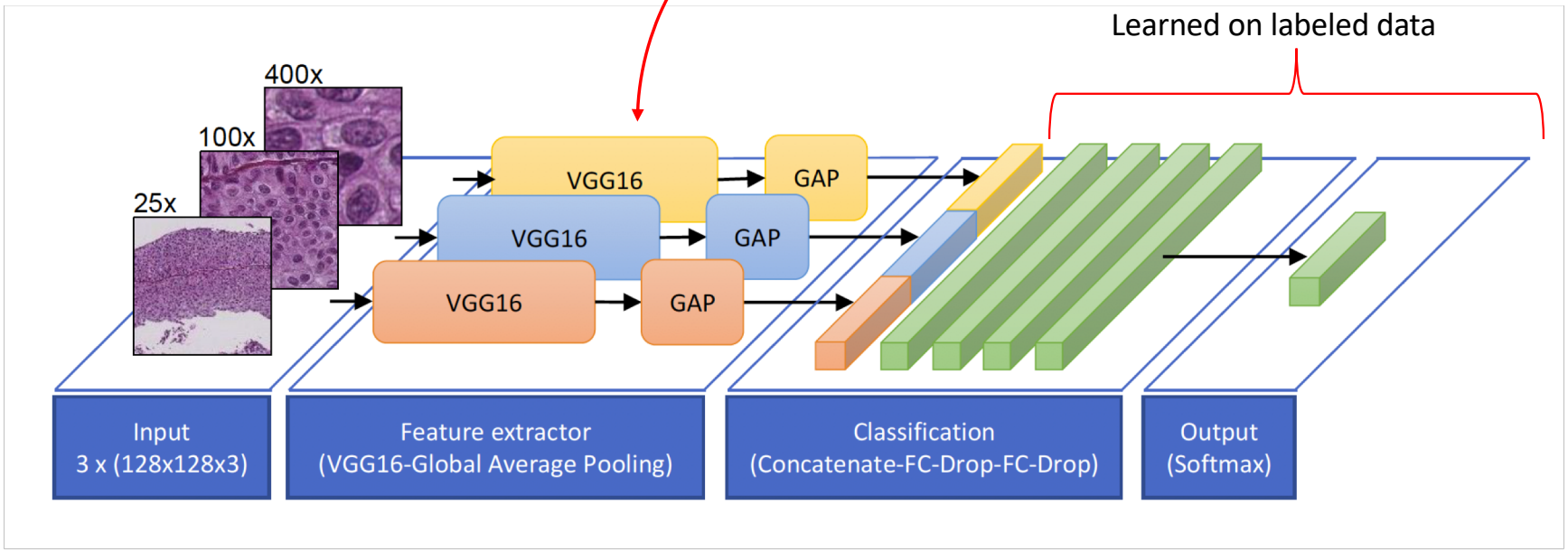


ROI extraction 2:

Using transfer-learning in multiscale.
VGG16 networks at three different scale, concatenating FV + fully connected layers trained on (relatively small set of) labelled data

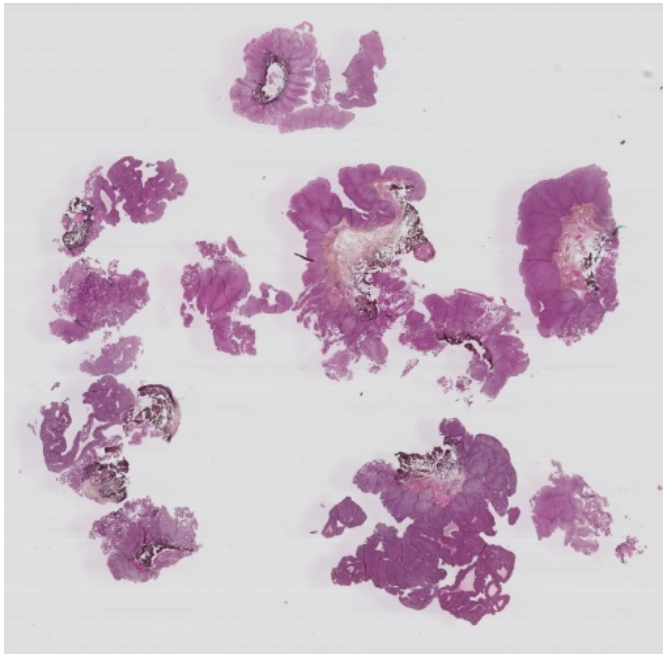




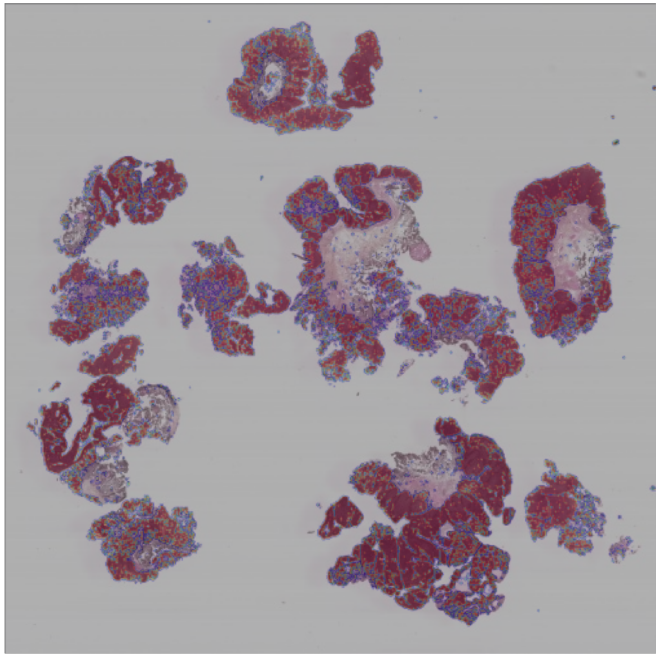


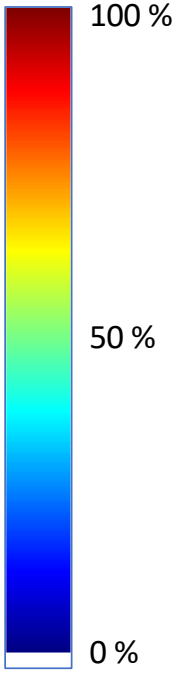
Heat Maps – example class

Original image



Urothelium tissue

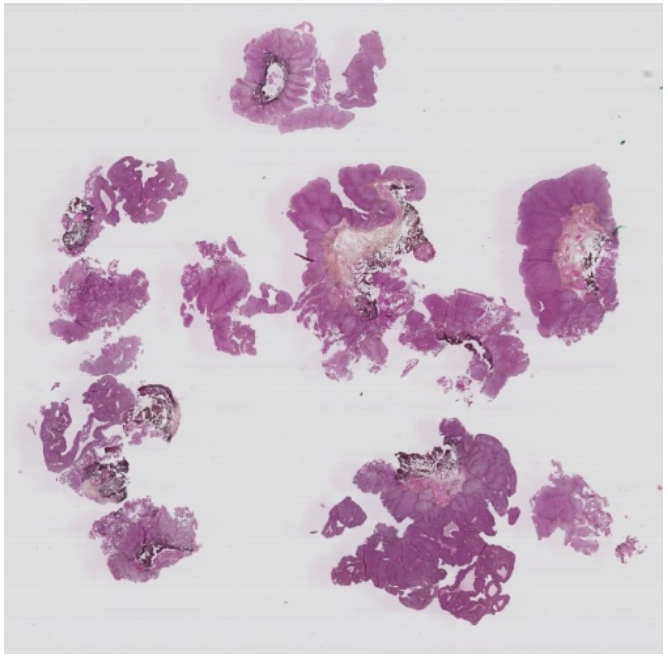




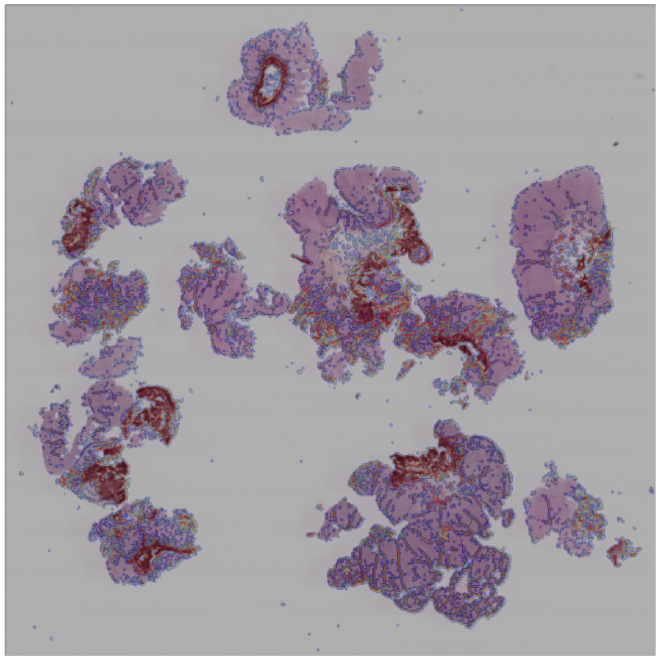
- Heat maps are post processed by applying a Gaussian filter kernel with standard deviation of $\sigma=0.6$ to smooth the image.

Heat Maps – example class

Original image



Damaged tissue



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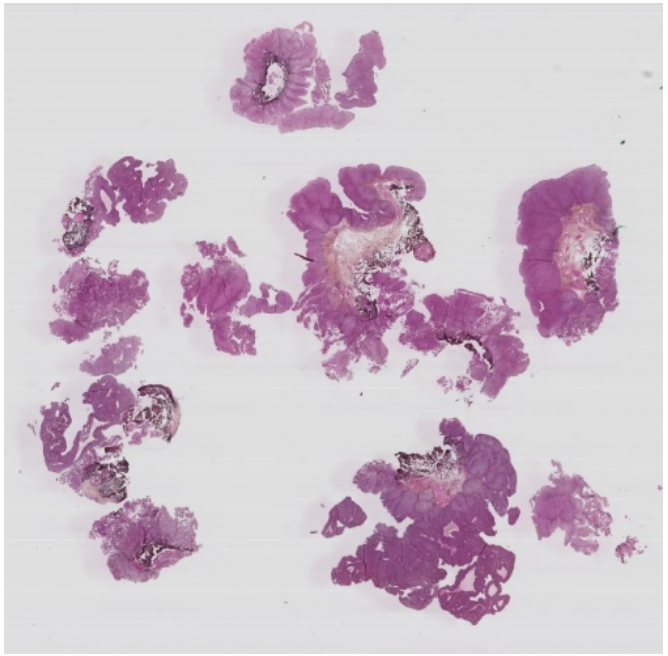
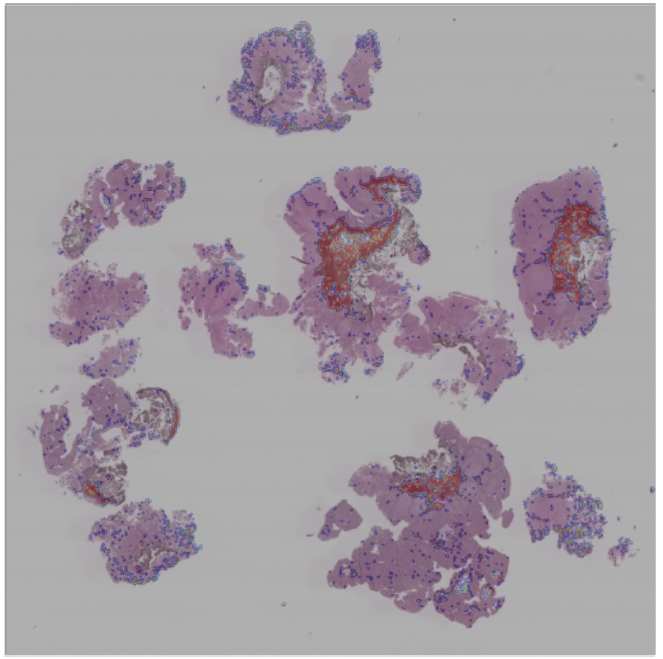
Heat Maps – example class

Original image



Stroma tissue



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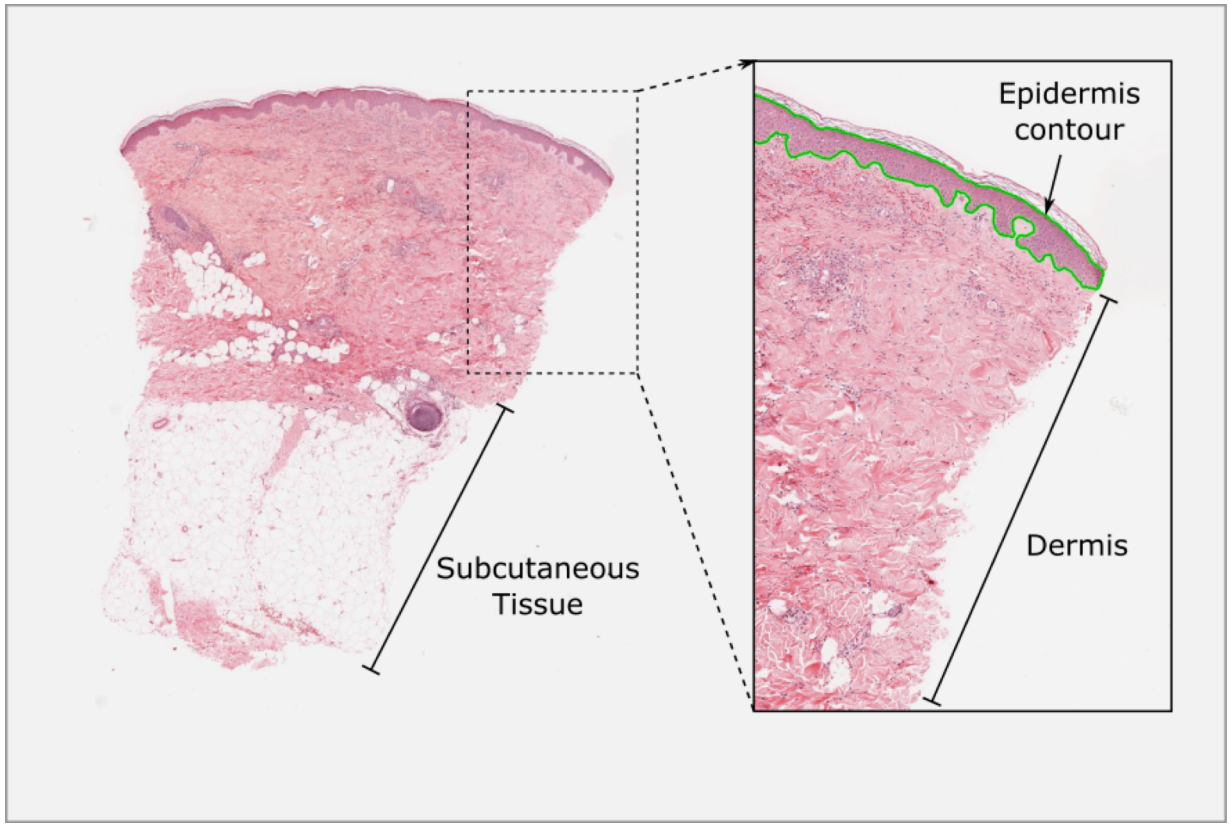
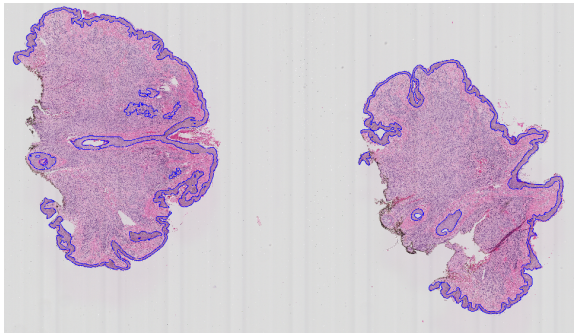
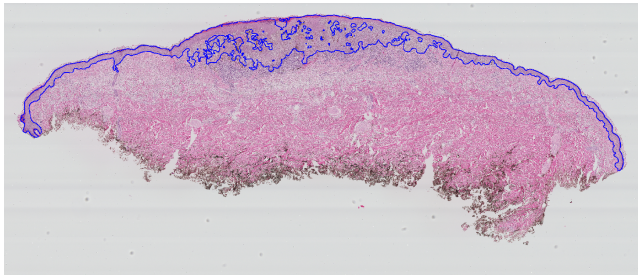
Melanoma : Epidermis segmentation





benign



Malignant

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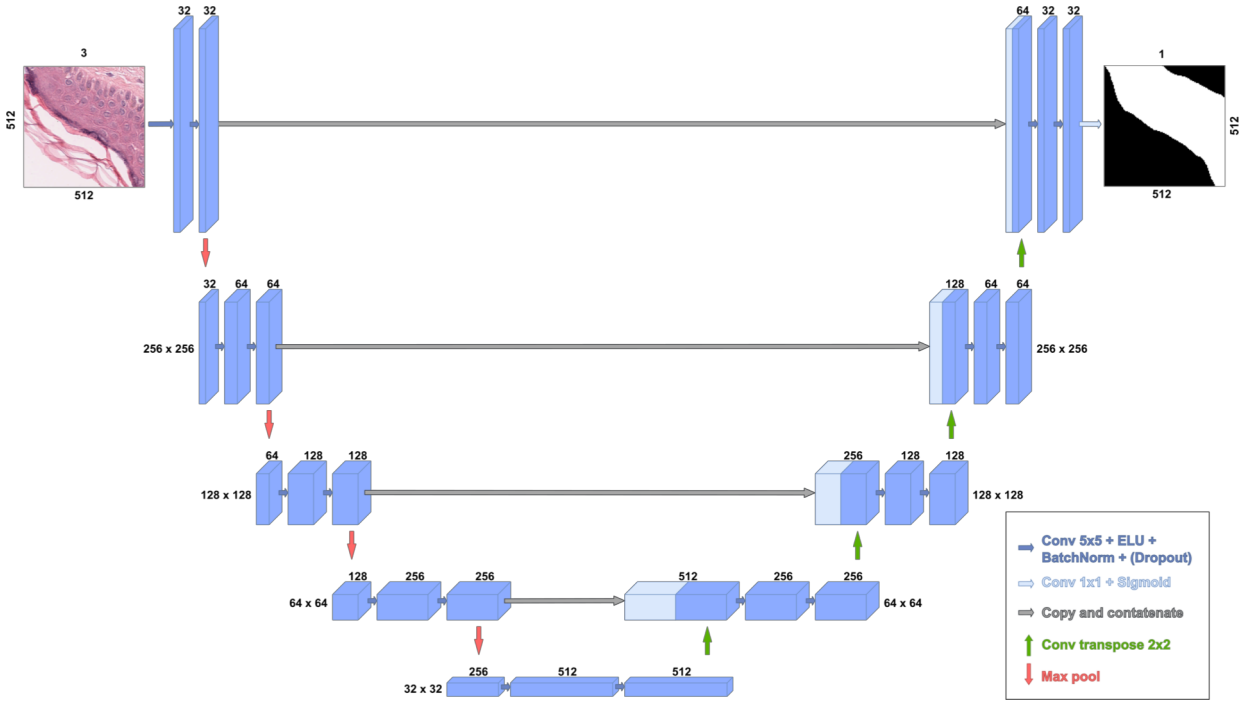
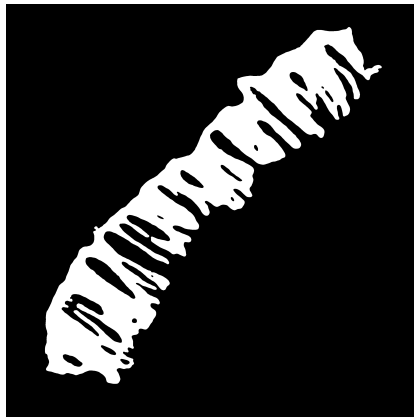
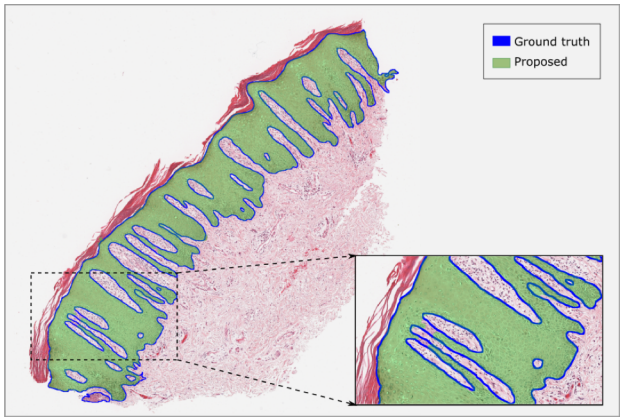
Epidermis segmentation – U-Net approach







Method	#failed	Mean value			
		$\mathcal{A}_{PPV}$	$\mathcal{A}_{SEN}$	$\mathcal{A}_{DSC}$	$\mathcal{A}_{MCC}$
CET	0	0.35	**0.99**	0.47	0.52
GTSA	21	0.73	0.31	0.39	0.42
THM	17	0.69	0.38	0.45	0.47
PASC	0	0.65	0.84	0.68	N/A
Proposed	0	**0.89**	0.92	**0.89**	**0.89**

Safer births

Sensor signals

- Fetal heart rate
- Resucitation signals (ECG, BMV)
- Video of rescucitation

Laerdal helping save lives

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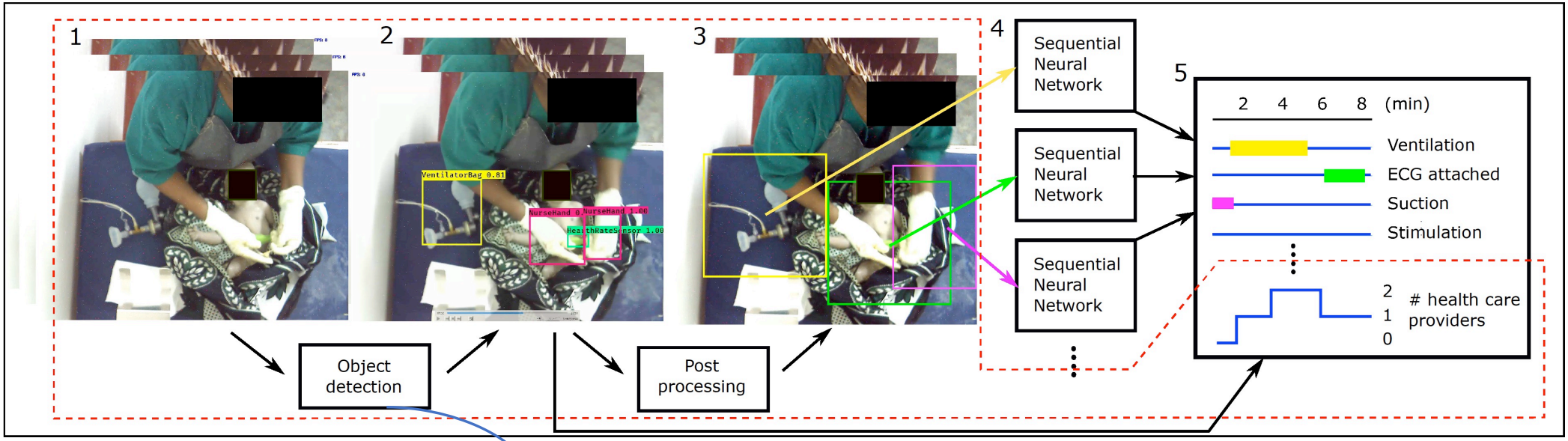
Video analysis

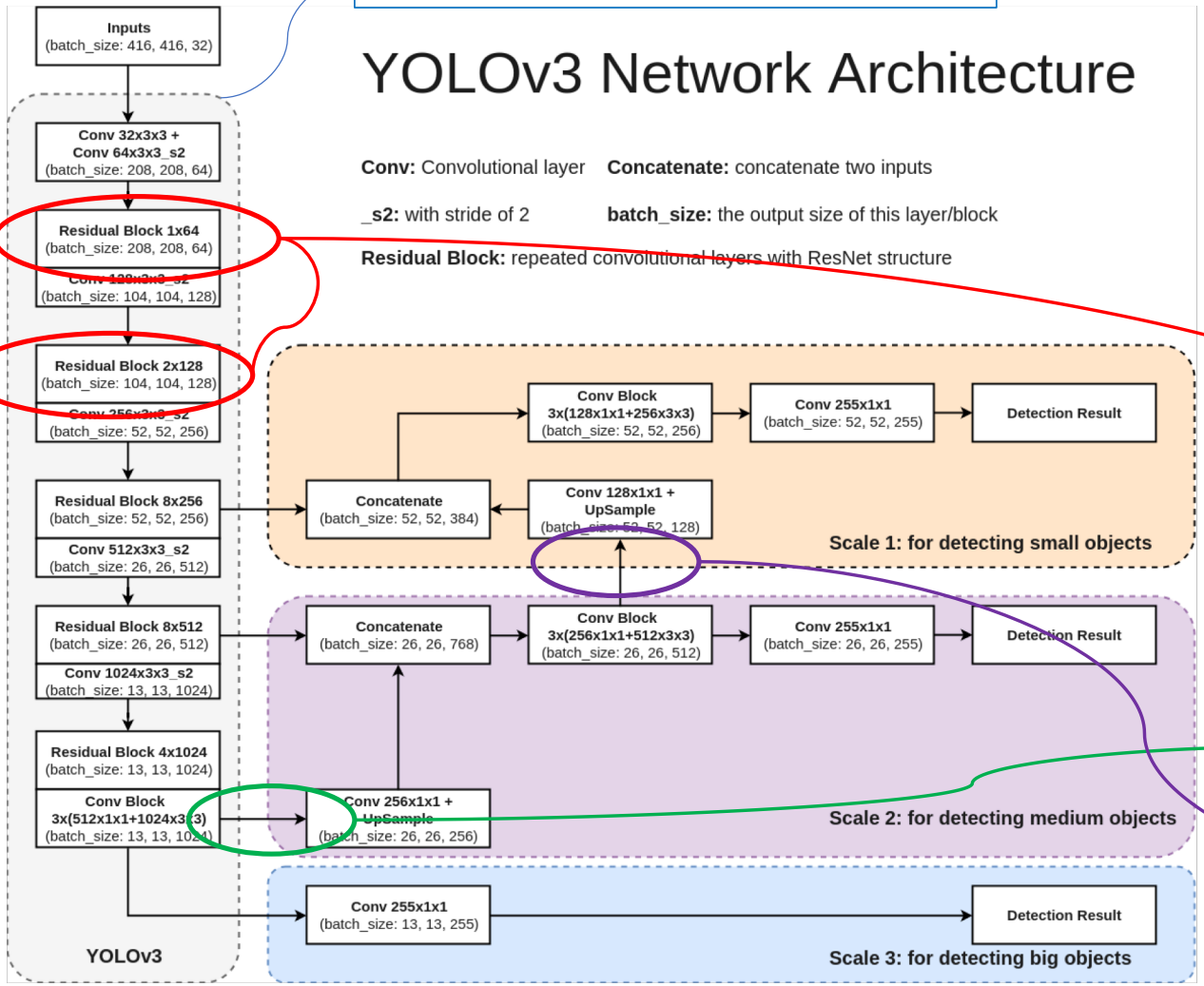
activity detection system for newborn resuscitation videos

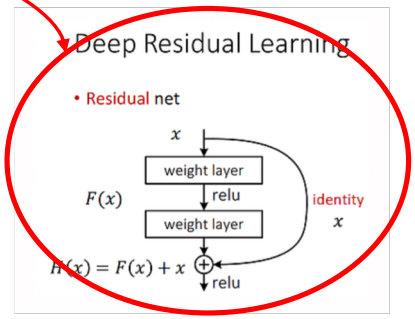


Tried different things. So far best results using the pretrained model of YOLOV3, and continue training on our data

Darknet-53 (53 conv-layers) trained on Imagenet (feature extractor)

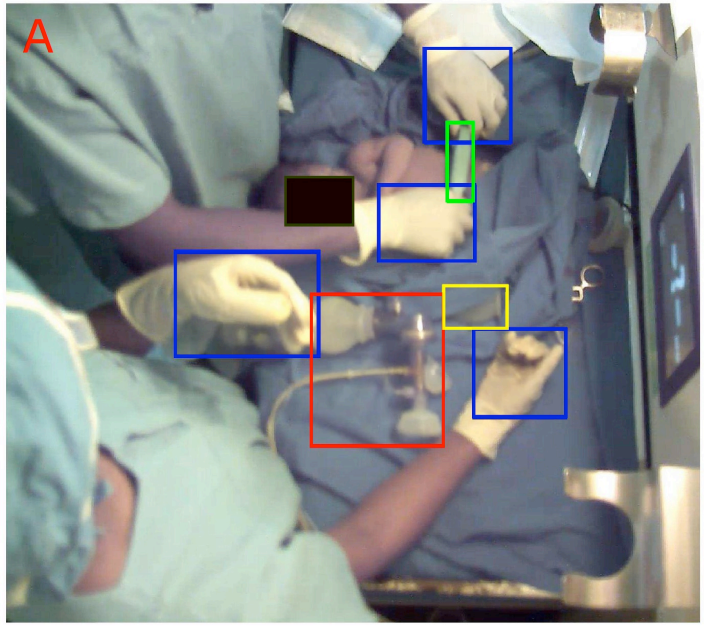
75 conv layers, no fully connected layers.
Conv layer with stride 2 is used for downsampling (no pooling)
ResNet for improved feature learning (skip connections)
FPN for utilizing multiscale
Multi-label classification

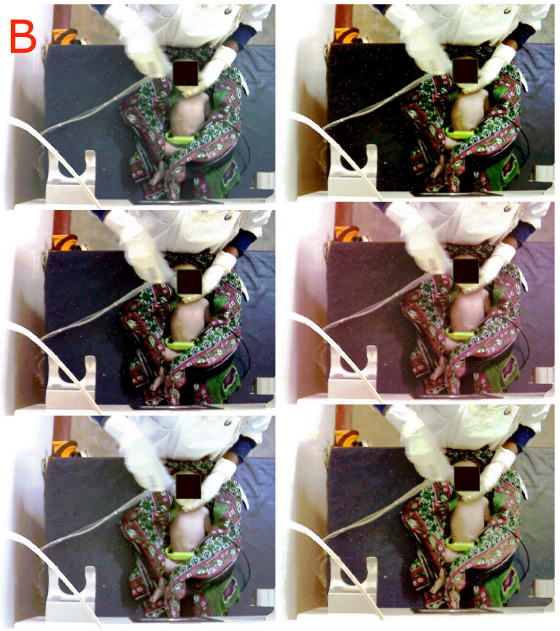


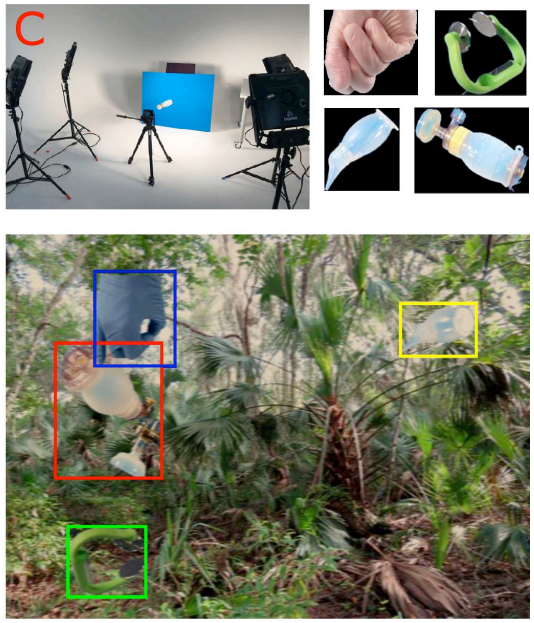


FPN: Feature Pyramid Network

Never enough labeled data! Training data (video, augmented, synthetic)





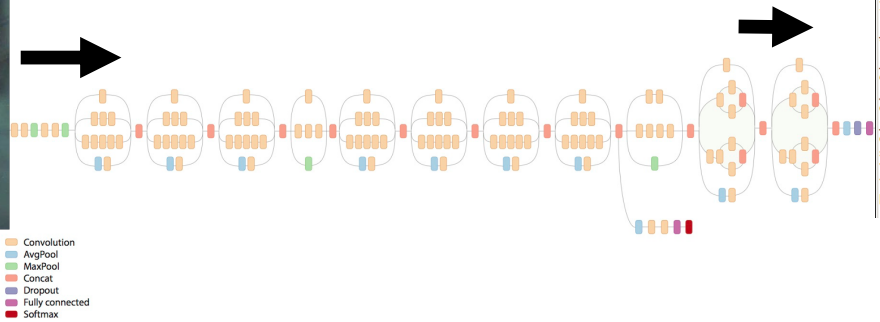


Object detection and tracking using YOLO v3 and post processing

Ventilations

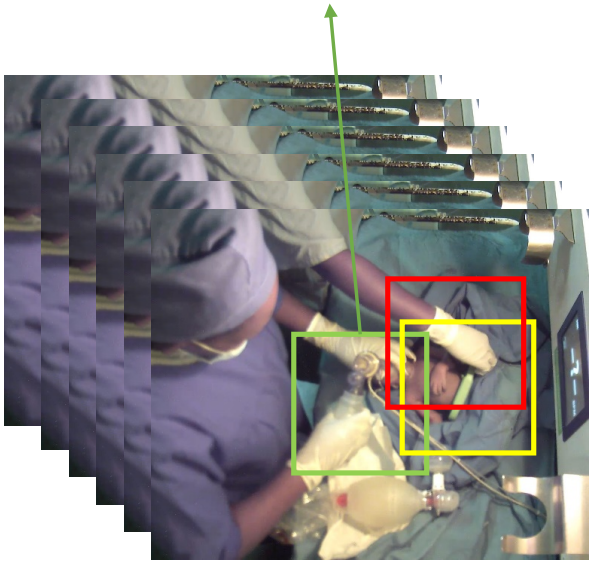
Not Ventilations

- Extract features from images using Inception_v3
- Input sequence of feature vectors to LSTM network trained on the idividual activities
  - Ex: ventilations or not
  - Augmentation (noise, blur, flip, rotate, crop)

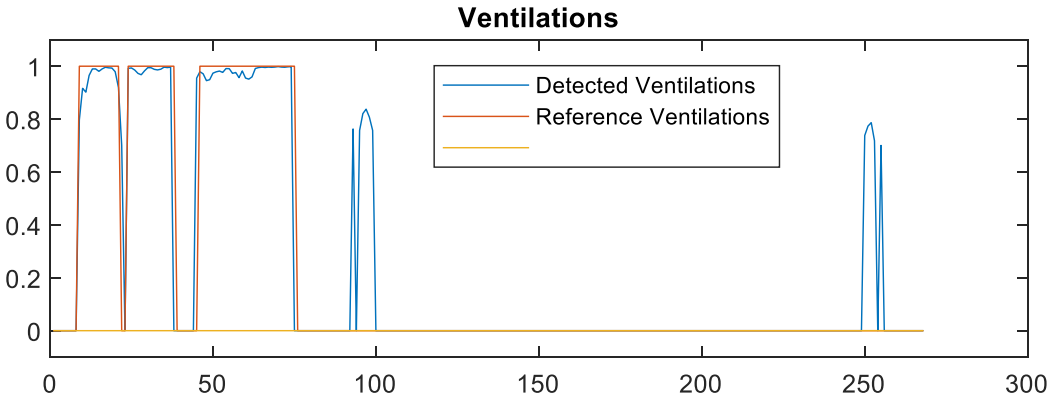


Layer (type)	Output Shape	Param #
lstm_1 (LSTM)	(None, 30, 2048)	33562624
lstm_2 (LSTM)	(None, 2048)	33562624
dense_1 (Dense)	(None, 512)	1049088
dropout_1 (Dropout)	(None, 512)	0
dense_2 (Dense)	(None, 2)	1026

Total params: 68,175,362
Trainable params: 68,175,362
Non-trainable params: 0



Validation acc 90% (using only RGB)

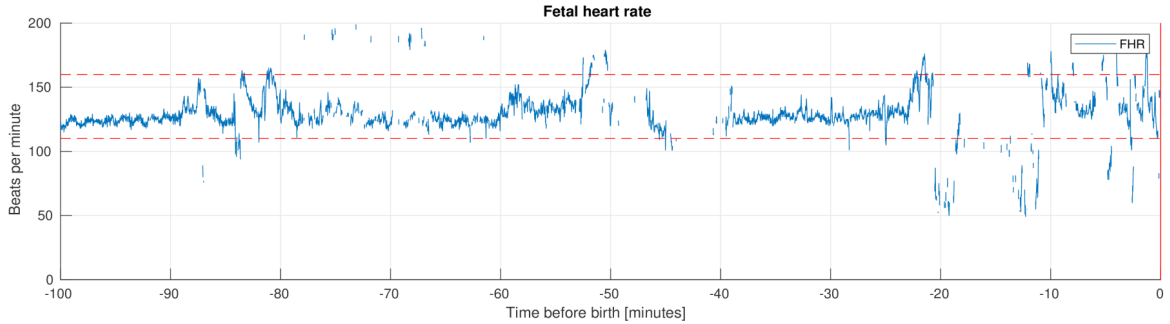


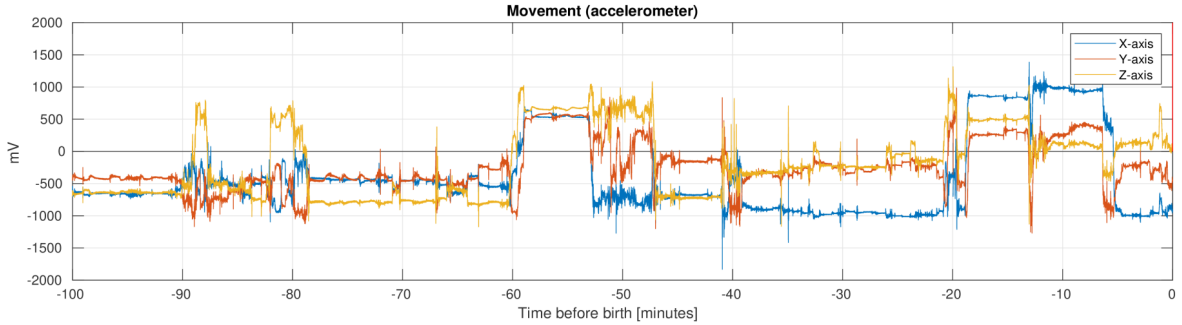
Working on: i3d (inception structure but for 3d (video) , one for RGB video and one for optical flow stream

Fetal heart rate - Moyo

Possible to predict outcome at earlier stage?

Detect fetus in need for care?
(Intrauterine intervention / C-section)





Other ongoing projects on deep learning at UiS

Novel Deep Neural Network Architectures for Fake news Detection in Social Networks and News Media

DeepRTP - Deep learning the real-time properties of strongly correlated quantum fields, deeprtp.uis.no

Future Energy Hub – AI and Machine Learning in energy informatics and smart cities

Segmentation of myocardium in cardiac magnetic resconanse images

Identifying areas at risk from perfusion CT images after cerebral ischemic stroke

Identification and classification of dementia types from brain MRI