TissueNet: Detect Lesions in Cervical Biopsies

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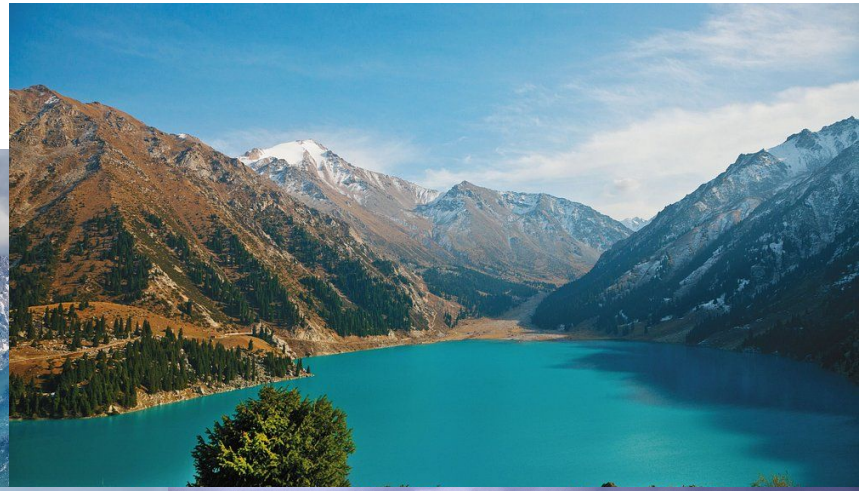
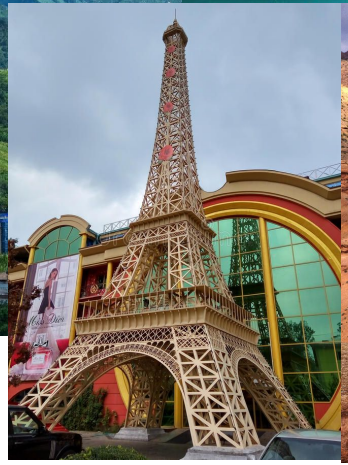




About me

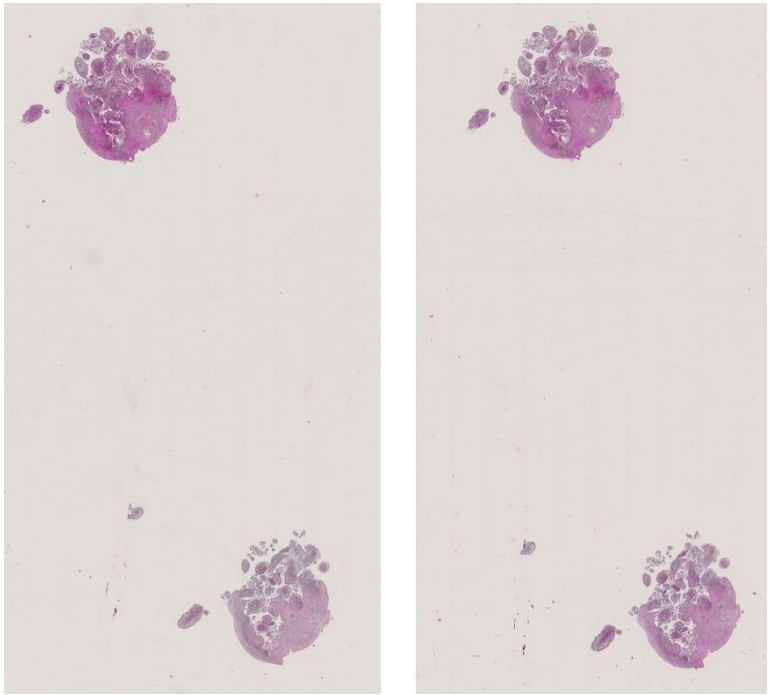
- PhD student in Computer Graphics at the University of Montréal (Canada)
  - Learning-based Posing of 3D Characters via Bitmap Sketches
- BSc & MSc in Mathematics at the Novosibirsk State University (Russia)
- Ingénieur in Modeling and numerical simulation at ENSTA ParisTech (France)
  - Maxwell’s equations in metamaterials
- MSc-level in Machine Learning at Yandex School of Data Analysis (Russia)
- CAD systems
  - Elasticity, heat transfer, geometric problems
- Chatbot / Virtual assistant
- Involved in educational programs at Computer Science Center (Russia)
  - Teacher of Machine Learning and Deep Learning courses
- Competitive Machine Learning

Task description

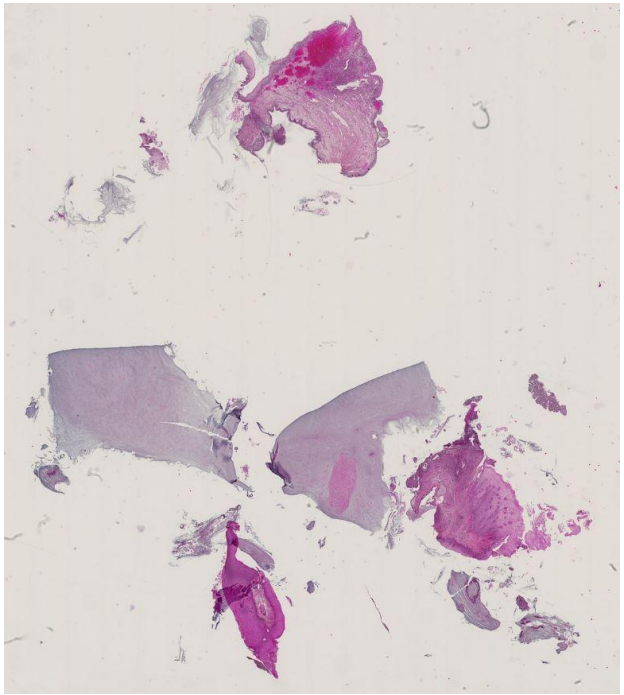
- Image classification task
- ~1k train images with extremely high resolution
  - ~150,000 x 85,000 pixels (~30 Gb RAM)
- 4 ordinal classes
- Weighted Class Score
- https://www.drivendata.org/competitions/67/competition-cervical-biopsy/

Very big images

C07_B016_S21 (80,128 x 87,296)



C07_B089_S21 (80,384 x 71,424)



Ordinal classes

- 0: benign (normal or subnormal)
- 1: low malignant potential (low grade squamous intraepithelial lesion)
- 2: high malignant potential (high grade squamous intraepithelial lesion)
- 3: invasive cancer (invasive squamous carcinoma)

Performance metric

ERROR TABLE

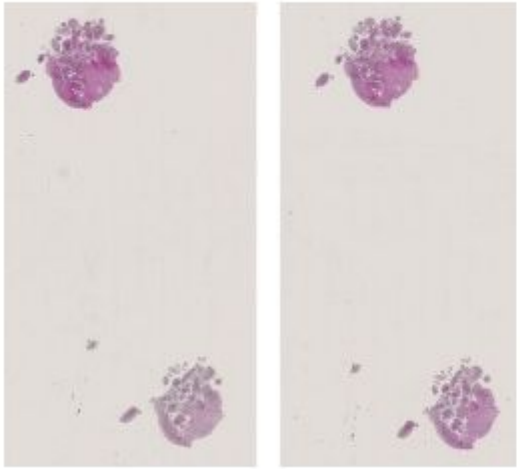
	Class 0 (pred)	Class 1 (pred)	Class 2 (pred)	Class 3 (pred)
Class 0 (actual)	0.0	0.1	0.7	1.0
Class 1 (actual)	0.1	0.0	0.3	0.7
Class 2 (actual)	0.7	0.3	0.0	0.3
Class 3 (actual)	1.0	0.7	0.3	0.0

Image downsampling

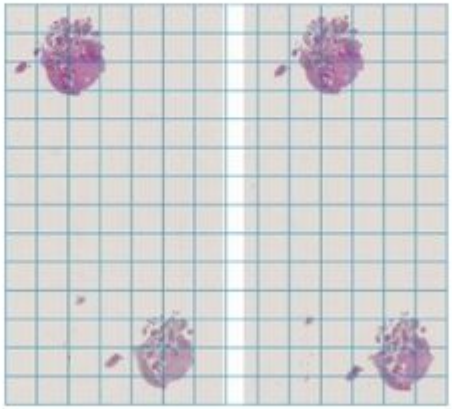
- It’s not possible (at least now) to work with such big images which do not fit ordinary computer with 16-32 or even 64 Gb RAM
- We need to downsample it with minimal loss of the information
- Fixed 16x downsampled resolution (~5,000 x 5,000 --- 10,000 x 10,000)

Tiles grid

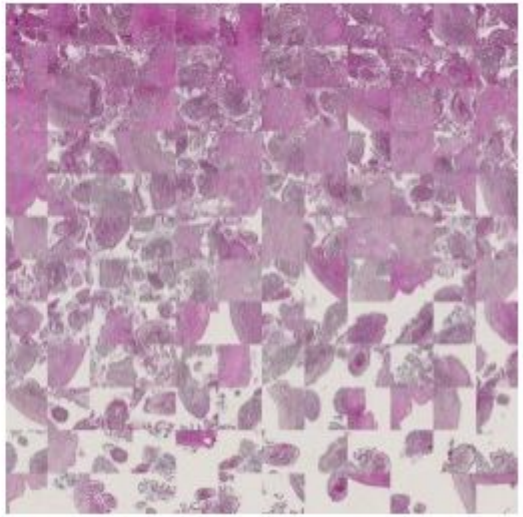
C07_B016_S21, page=p4 (5008x5456 pixels)



grid with 128x128 tiles



stacked top 144 tiles (1536x1536 pixels)



Tiles grid

- 36 tiles with 256 x 256 size
- 64 tiles with 192 x 192 size
- 144 tiles with 128 x 128 size

In all cases we have image with 1,536 x 1,536 input size

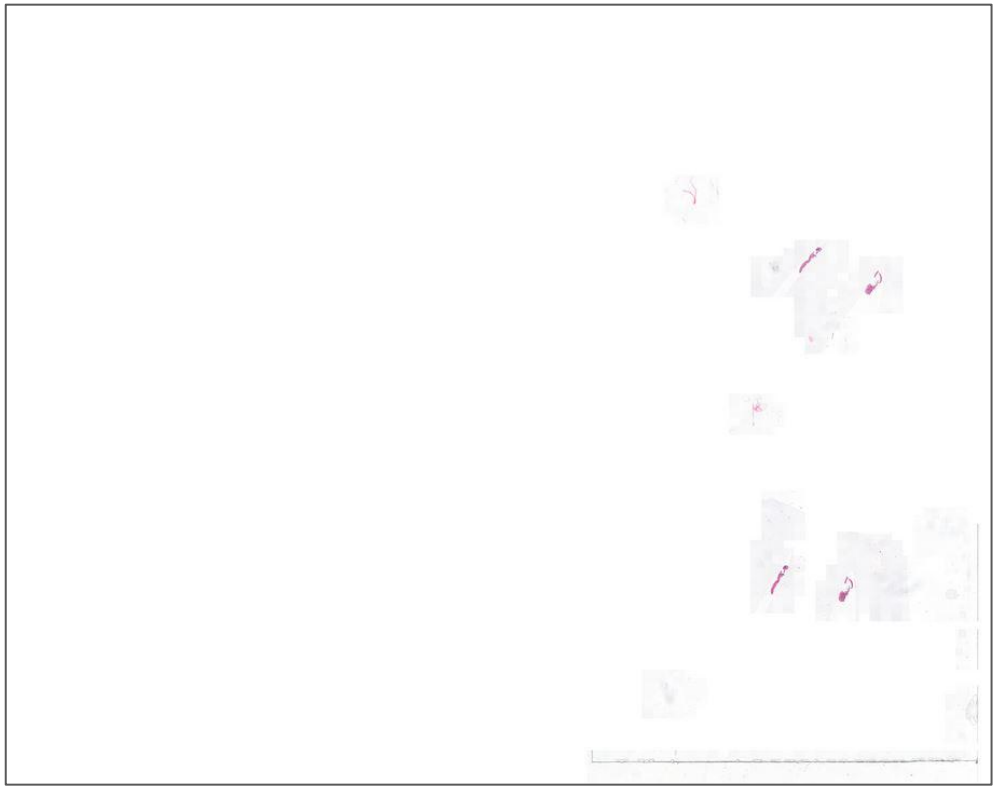
Issue: Huge image with white pixels

Insane huge sample

C13_B054_S11

with a lot of white pixels

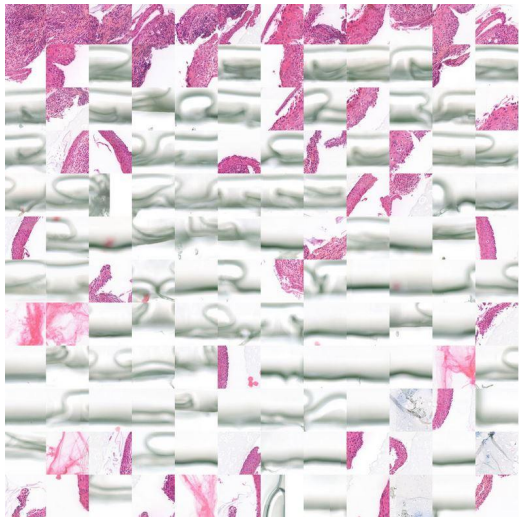
294,144 x 272,128



Issue: different downsampling levels

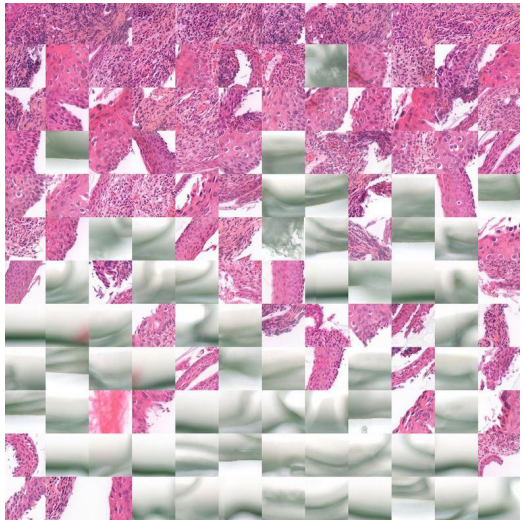
16x (18,384 x 17,008)

8x (36,768 x 34,016)

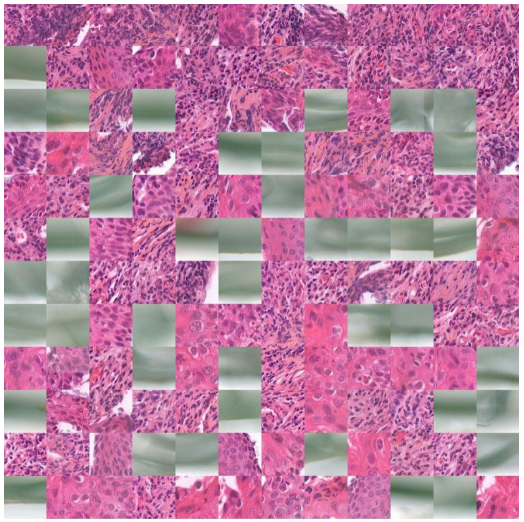


Issue: different downsampling levels

4x (73,536 x 68,032)



2x (147,072 x 136,064)



Classes encoding

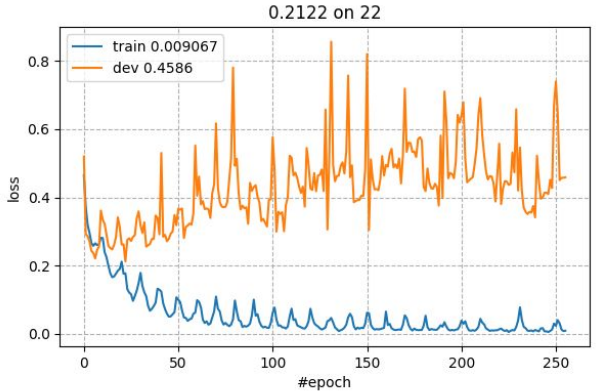
- 0 -> [0, 0, 0]: benign (normal or subnormal)
- 1 -> [1, 0, 0]: low malignant potential (low grade squamous intraepithelial lesion)
- 2 -> [1, 1, 0]: high malignant potential (high grade squamous intraepithelial lesion)
- 3 -> [1, 1, 1]: invasive cancer (invasive squamous carcinoma)

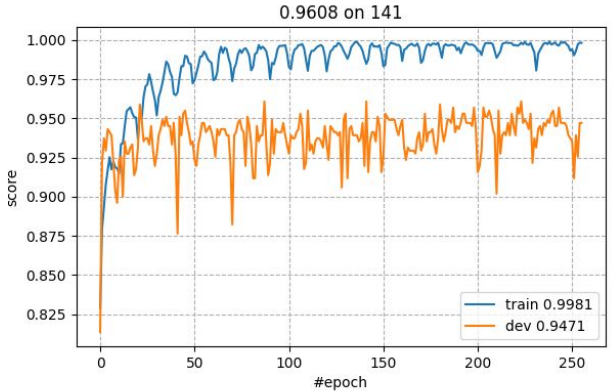
Neural Network Training

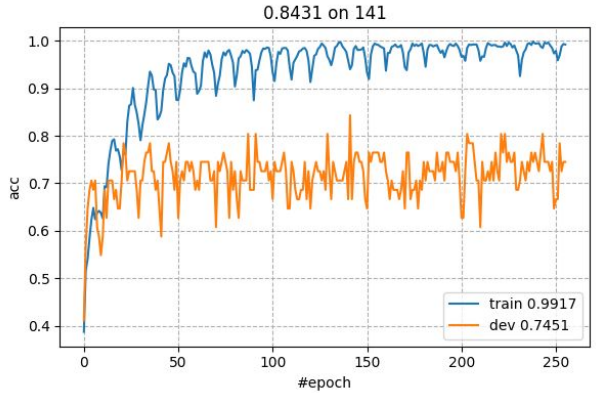
- Mixed precision
- EfficientNet-B0
- Binary Cross Entropy Loss
- Batch size 8 (20 Gb VRAM)
- AdamW with learning rate 1e-3 or 3e-4
- CosineAnealing scheduler
- Augmentations on tile and whole image levels: horizontal and vertical flips, rotate on 90
- Model ensembling (mean predictions of models from 8 folds)
- https://github.com/kbrodt/competition-cervical-biopsy

Learning curve

~24H Nvidia V100 32GB







Further research and questions

- Collaboration with researchers from medical science
- Use segmentation model to extract ROIs (region of interest)
- Use adaptive downsampling based on initial image resolution