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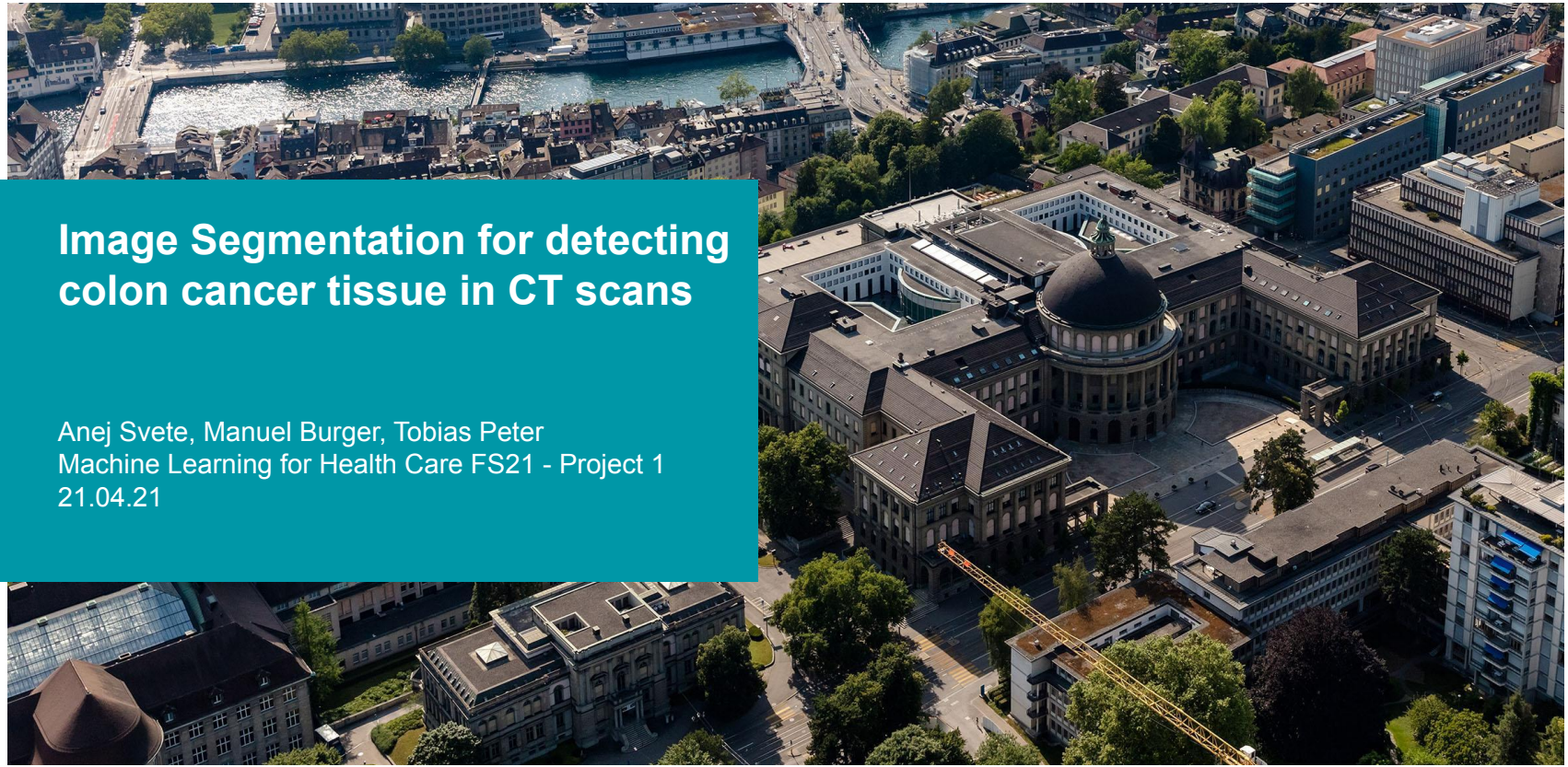


Image Segmentation for detecting colon cancer tissue in CT scans

Anej Svete, Manuel Burger, Tobias Peter

Machine Learning for Health Care FS21 - Project 1

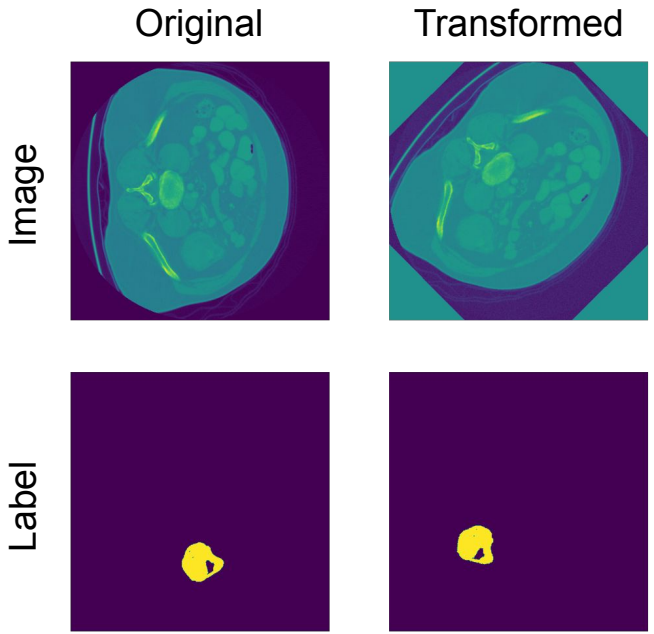
21.04.21

Outline

- Preprocessing
- Model Architecture
- Training and Loss
- Pretraining
- Ensemble
- Conclusion

Preprocessing

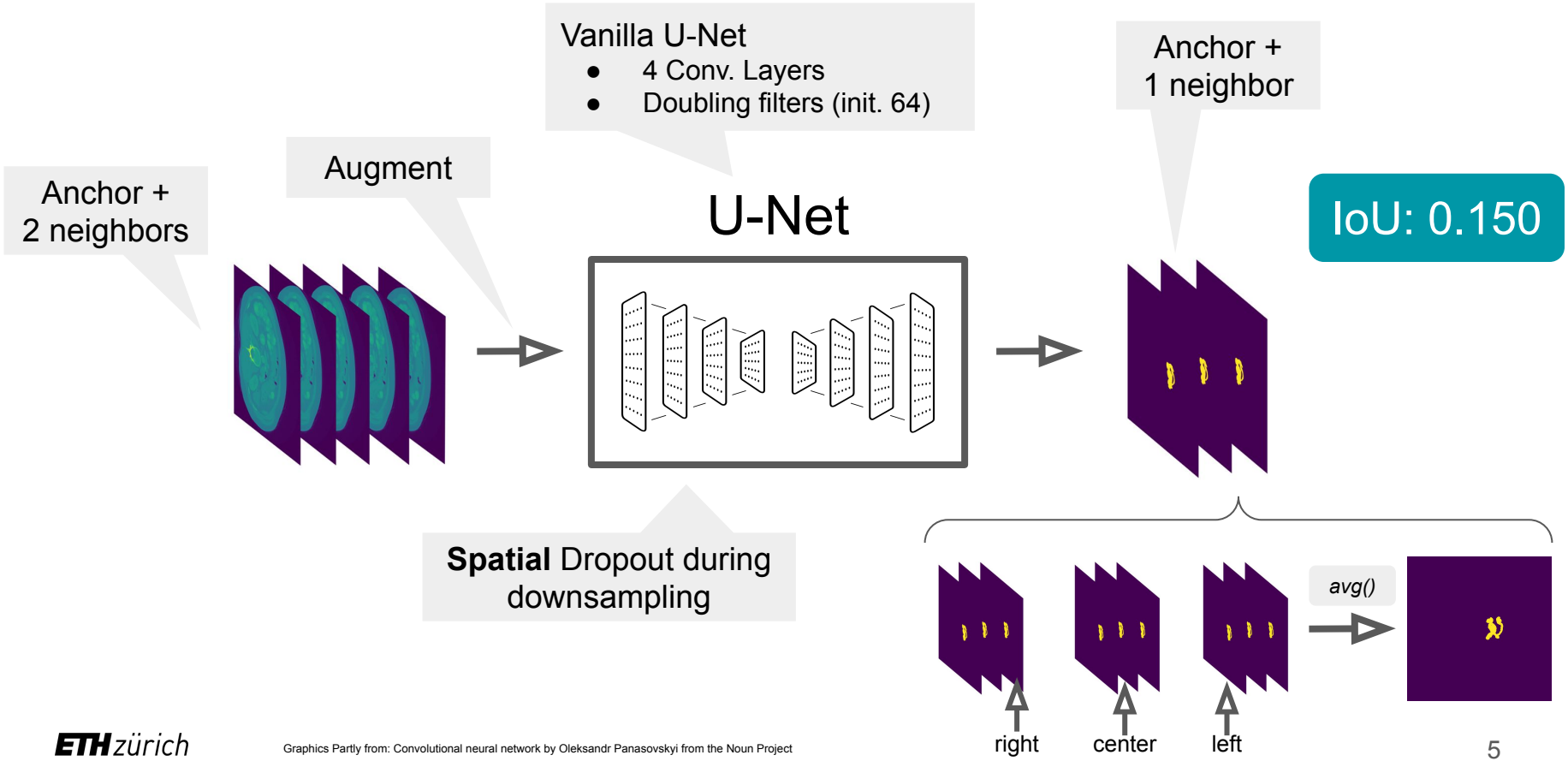
- Voxel size normalisation
- Images split into **5 layer input chunks** and **3 layer output chunks**
- Standardization/normalization ✗
- Data augmentation:
  - Flipping ✓
  - Rotation ✓
  - Gaussian Noise ✓
- Downsampling
  - Conservative: 45 % of samples containing cancer
  - Aggressive: 65 % of samples containing cancer



Training and Loss

- IoU-loss resulted in unsatisfactory outputs
  - Encouraged the prediction of *background* only
- Separate training on subsets of data for ***loss function selection***
  - IoU-loss
  - Tversky loss [1]
  - Focal loss [2]
  - Focal-Tversky loss [3]
- **Focal-Tversky loss** performed best
  - Enables easy-to-tune levels of trade-offs between FP and FN

Model Architecture



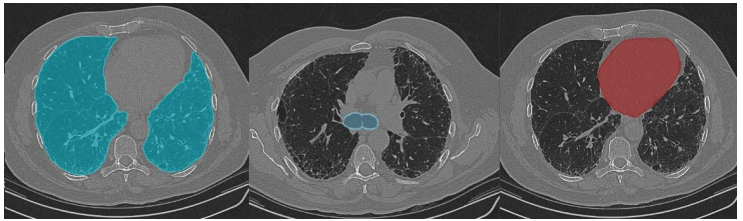
Graphics Partly from: Convolutional neural network by Oleksandr Panasovskyi from the Noun Project

Pretraining

Google Dataset Seach

Kaggle Dataset ~100 CT Scans

Limited Training Data

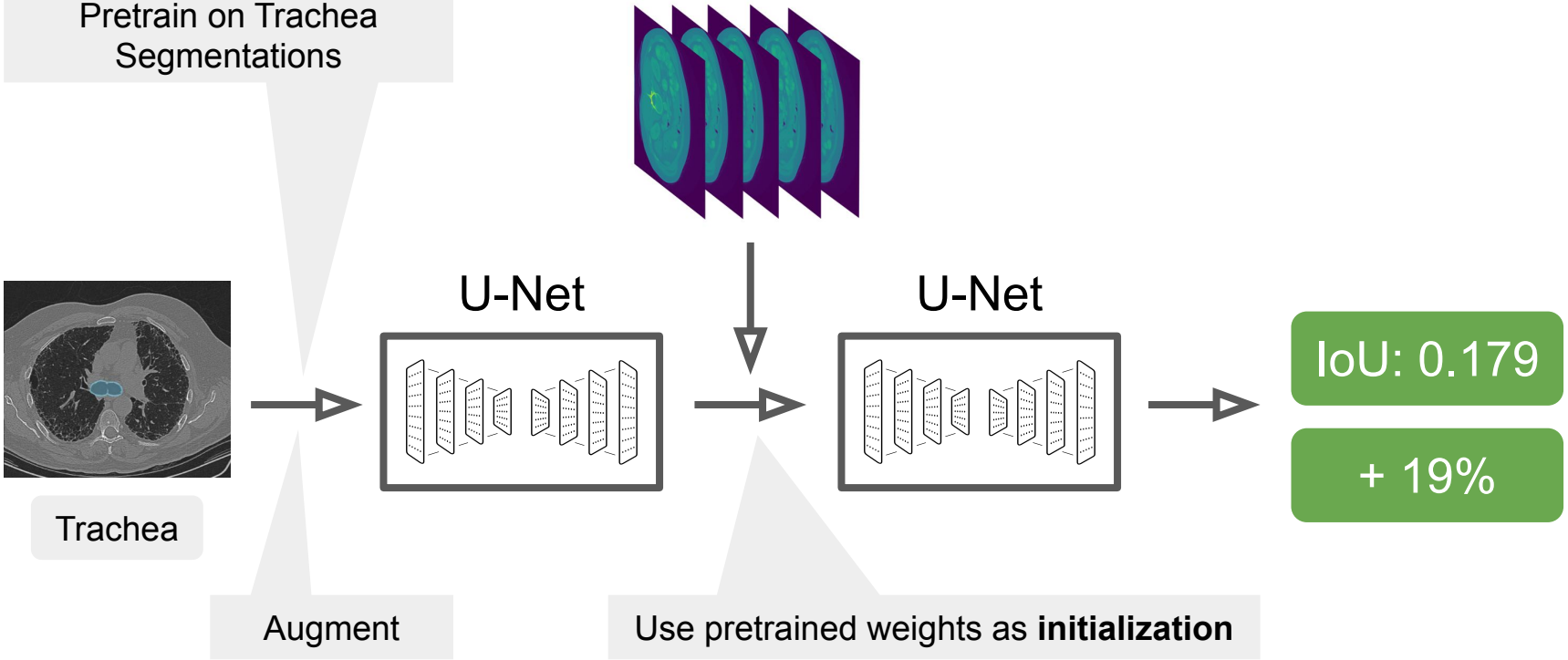


Lungs Trachea Heart

Same modality and resolution

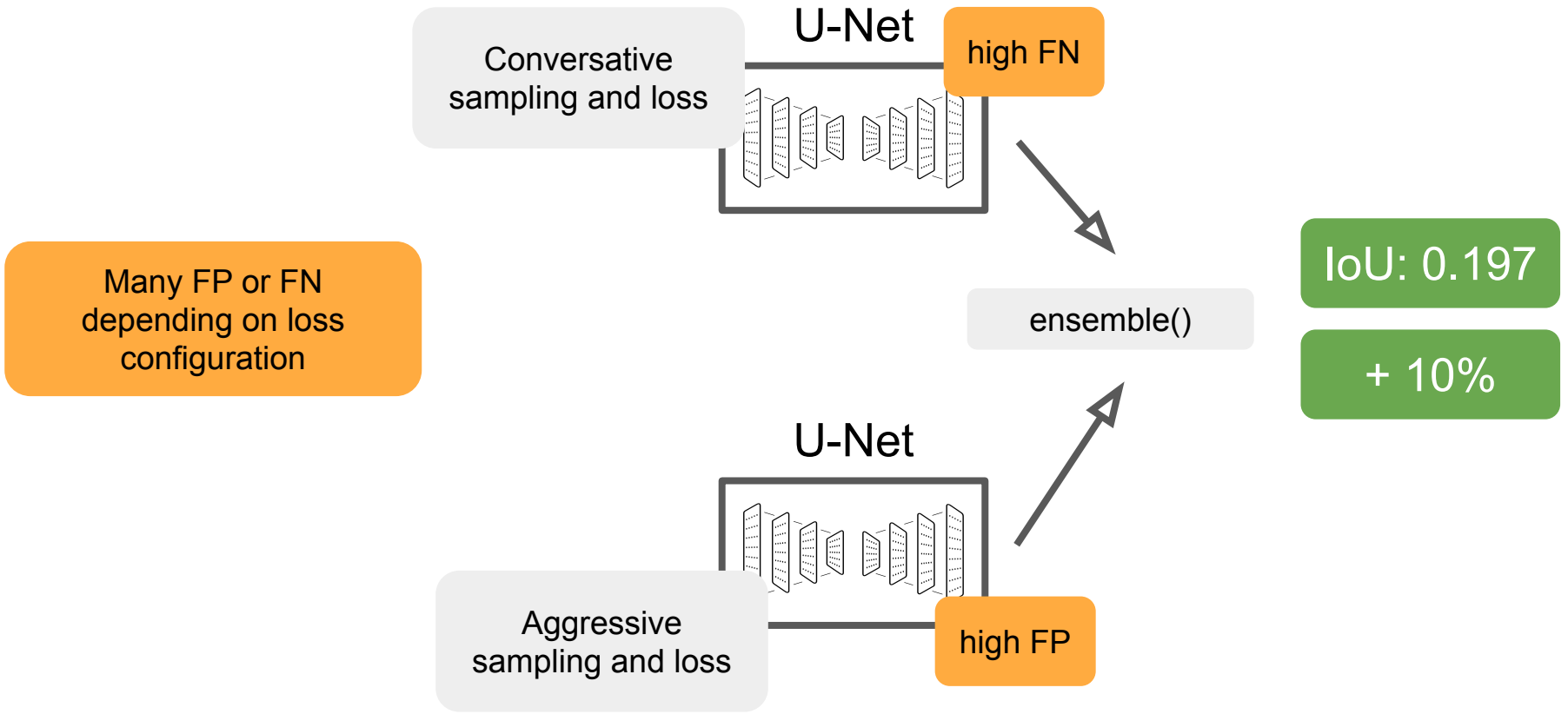
K´onya et al. Lung Segmentation Dataset (2000). https://www.kaggle.com/sandorkonya/ ct-lung-heart-trachea-segmentation.

Pretraining



K´onya et al. Lung Segmentation Dataset (2000). https://www.kaggle.com/sandorkonya/ ct-lung-heart-trachea-segmentation.

Ensemble


Conversative sampling and loss
U-Net
high FN
Many FP or FN depending on loss configuration
ensemble()
IoU: 0.197
+ 10%
U-Net
Aggressive sampling and loss
high FP

Summary of Results

On our validation set we obtained an IoU

- without pretraining (base): 0.150
- with pretraining: 0.179 (**+19%**)
- with tuning for more FP rather than FN: 0.168 (**+12%**)
- simple ensemble of the previous 2 models: 0.197 (**+31%**) → used for submission

Validation score was confirmed with a slightly higher test score of **0.203**.

Model	Description	IoU validation	IoU test
A	base model: without pretraining	0.150	
B	with pretraining	0.179	
C	with pretraining & higher focus on cancer (more FP)	0.168	
D	**submission: ensemble out of models B and C**	**0.197**	**0.203**

Discussion and Conclusion

- Significant variance between IoU for individual subjects (0.00 - 0.69).
- Thus, we doubt that it could benefit a medical professional.
- But we see following opportunities for improvement:
  - Additional pre-training.
  - Appropriate post-processing: Filters and morphological transformations did **not** help.
  - Tailored loss-function, e.g. combination of Focal-Tversky loss and IoU.
- Additional idea: train a second model to just detect the presence of cancer in images - either directly integrated into the U-Net or as some form of post-processing - to reduce FP while keeping FN low.

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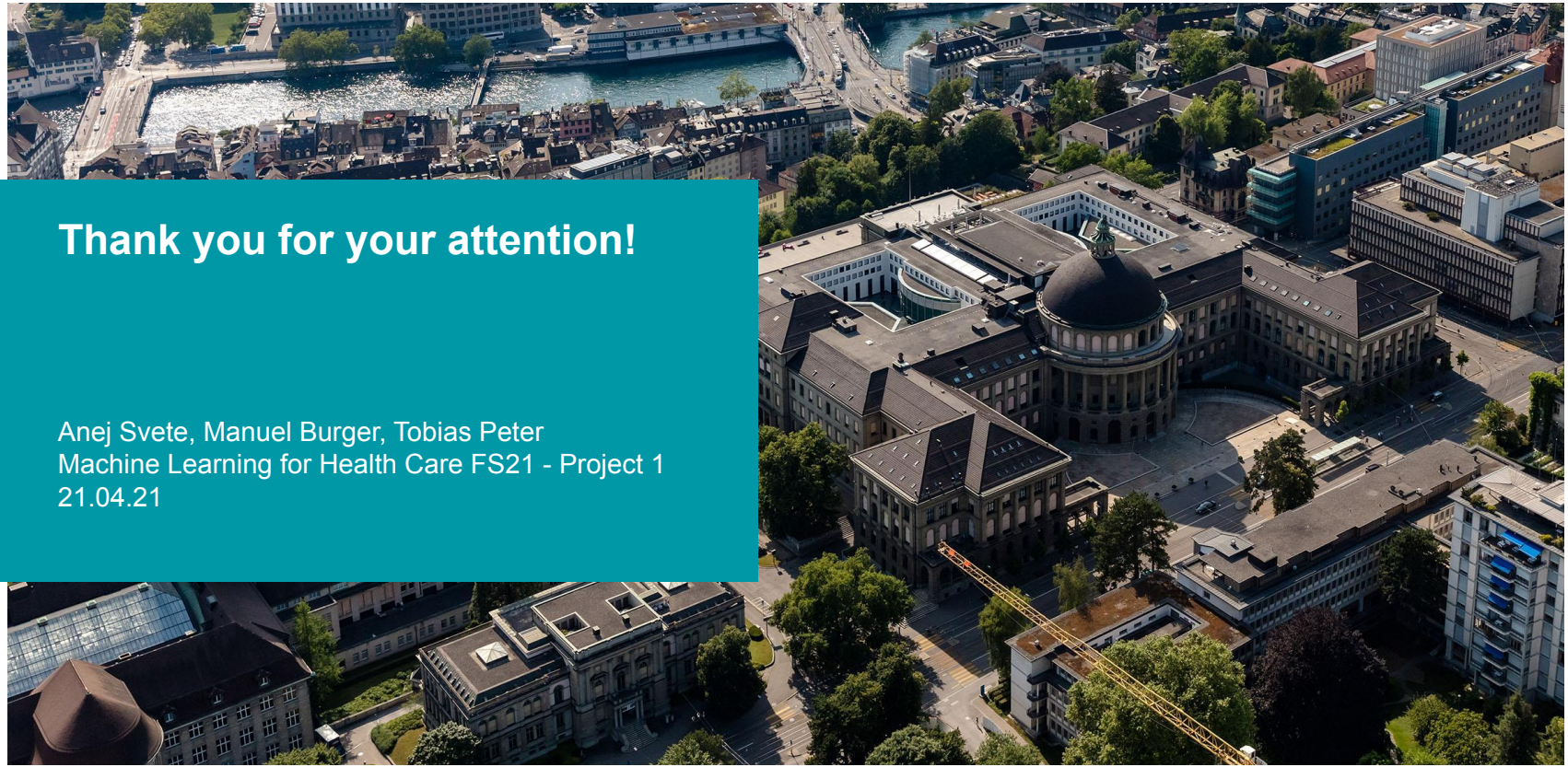

Thank you for your attention!

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References

[1] Seyed Sadegh Mohseni Salehi, Deniz Erdogmus, Ali Gholipour. **Tversky Loss Function for Image Segmentation Using 3D Fully Convolutional Deep Networks** (2017). https://arxiv.org/abs/1706. 05721

[2] Tsung-Yi Lin, Priya Goyal, Ross Girshick, Kaiming He, Piotr Dollar. **Focal Loss for Dense Object Detection** (2018). https://arxiv.org/abs/1708. 02002.

[3] Nabila Abraham and Naimul Mefraz Khan. **A Novel Focal Tversky Loss Function with Improved Attention U-Net for Lesion Segmentation** (2018). https://arxiv.org/abs/1810.07842

[4] Kaggle dataset. Chest CT Segmentation. https://www.kaggle.com/polomarco/chest-ct-segmentation.

[5] Konya et al. Lung Segmentation Dataset (2000). https://www.kaggle.com/sandorkonya/ct-lung-heart-trachea-segmentation.