AI in Medicine I
WiSe 2022/23

Technical University Munich
Department of Informatics

I31 - AI in Medicine and Healthcare
I32 - Computational Imaging in AI and Medicine

Theoretical exercise 1 **31. Oct. 2022**

Image Segmentation

The solutions will be discussed in the tutorial session

03. Nov 2022, 4-6 p.m. in lecture hall 5901.EG.051

For questions regarding this exercise sheet, please contact: `felix.meissen@tum.de`
For general questions, please contact: `course.aim-lab@med.tum.de`

1 Multiple choice questions

Answer the following multiple choice questions. For every question, at least one of the provided answers is correct. A point is rewarded only if all answers for a given question are correct.

1. (1 point) Which information can be extracted from medical images via segmentation?
   - ◯ Size of the segmented structures
   - ◯ Position of segmented structures
   - ◯ Shape of the segmented structures
   - ◯ Texture of the segmented structures
2. (1 point) Which of the following classes of segmentation algorithms are fully automatic during inference, i.e. do not require user input for each new image?
   - ◯ Atlas-based segmentation
   - ◯ Random forests
   - ◯ Region growing
   - ◯ Deep-learning algorithms
   - ◯ Graph Cut
3. (1 point) Deep-learning based semantic segmentation of a 3D medical scan is commonly phrased as which learning problem?
   - ◯ Voxel-wise classification
   - ◯ Regression of the surface boundary
   - ◯ Localization of all imaged organs
4. (1 point) A U-Net is an example of what type of neural network architectures?
   - ◯ Recurrent neural network
   - ◯ Encoder-decoder network
   - ◯ Decoder network

- ◯ Generative adversarial network
- ◯ Transformer

5. (1 point) What are downsides of segmentation via dense classification?
   - ◯ Redundant computations
   - ◯ Requires large models
   - ◯ Slow inference
   - ◯ Can not be applied to large images (bigger than 512×512 pixels)

2 Open questions

1. (2 points) Artifacts in medical images can severely degrade the performance of segmentation algorithms. Name two potential causes of artifacts in medical images.

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2. (5 points) Manual segmentations by medical specialists are often used as ground truth when evaluating the performance of segmentation algorithms. Name three shortcomings that are associated with such expert-derived annotations. Also, provide two potential solutions to alleviate this problem.

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3. (2 points) Why is the U-Net such a good architecture for image-to-image translation?

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3 Evaluation metrics

Given the following 6×6 binary segmentations, with pixels marked with a '1' belonging to the foreground object, and pixels marked with '0' are background.

0	0	0	0	1	0
0	0	0	0	1	0
0	0	1	1	1	0
0	1	1	1	1	0
0	1	1	1	1	1
0	0	1	1	1	0

Reference

0	0	0	0	0	0
0	1	0	0	0	0
0	1	1	0	1	0
0	1	1	1	0	0
0	1	1	0	1	1
0	0	0	0	0	0

Prediction

1. (2 points) Calculate the number of true and false positives, true and false negatives.

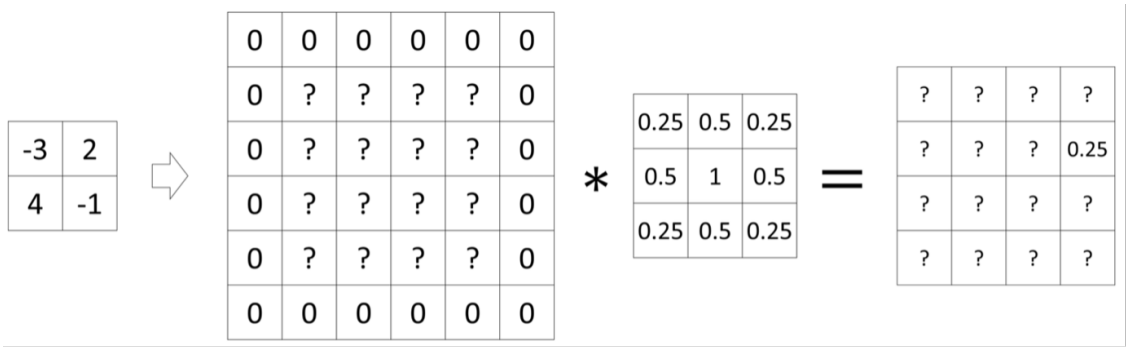
2. (6 points) Calculate the values for precision, recall, specificity, Dice similarity coefficient, Jaccard Index, and Hausdorff distance.

3. (1 point) Discuss briefly whether specificity is a useful metric for evaluating segmentation algorithms.

4. (2 points) Show that the Dice similarity coefficient is equivalent to the F1 score.

4 Upsampling

1. (2 points) Upsample the given 2×2 feature map by a factor of 2 using the given weight kernel and a zero-fill (or "bed of nails") strategy. Fill in all cells marked with '?'.



5 Pitfalls of segmentation metrics

1. (3 points) Calculate the Dice similarity coefficient for both predicted segmentation masks below. Do you see a problem here?

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	1	1	1	1	0	0
0	0	1	1	1	1	0	0
0	0	1	1	1	1	0	0
0	0	1	1	1	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Reference

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	0
0	0	0	1	1	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Prediction #1

0	0	0	0	0	0	0	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0

Prediction #2