On the Importance of Features and Locations in Patch-Based Segmentation of Parotid Glands

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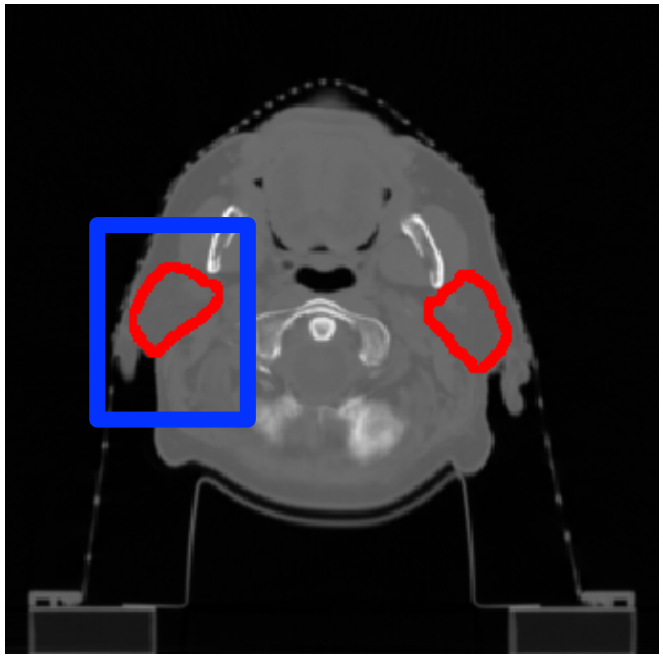
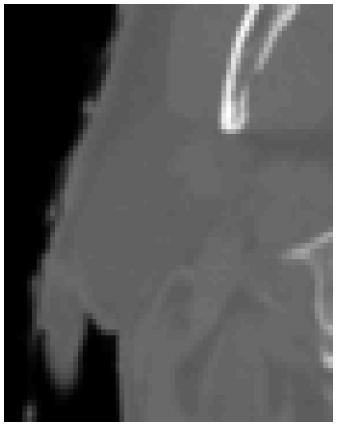
Segmentation of Parotid Glands

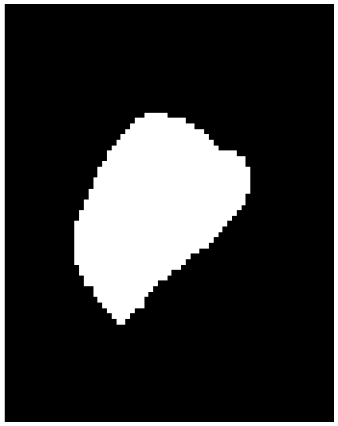
CT Slice with segmentations



Zoom

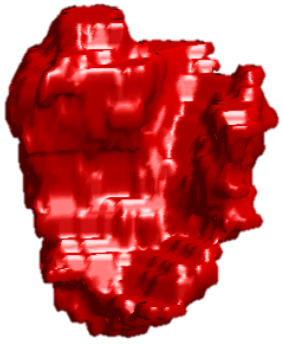


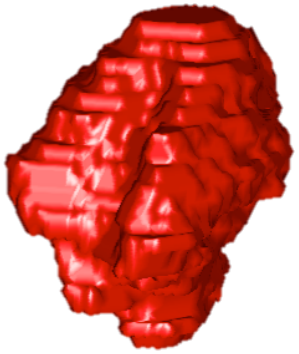
Segmentation



Zoom & Clipping

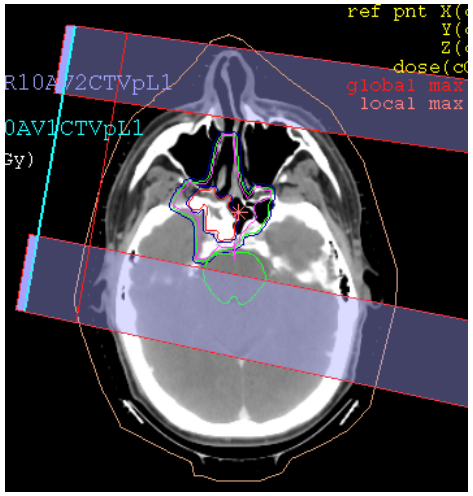
Surface renderings

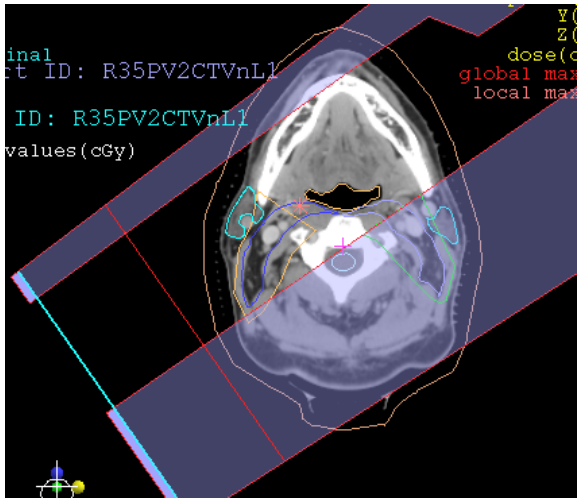


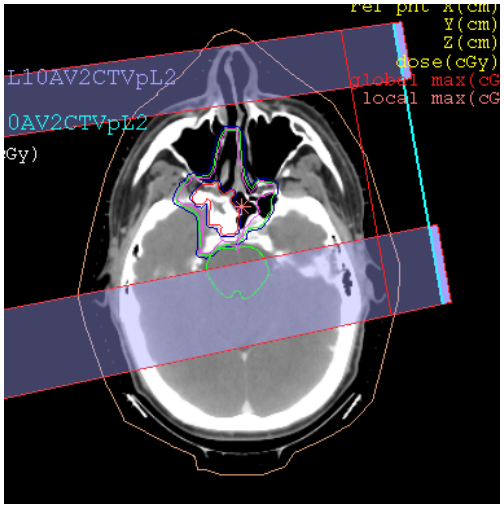


Segmentation of Parotid Glands

- Parotid glands are organs at risk
  - Irradiation can cause xerostomia
  - Difficulties for mastication, deglutition, speech
- Adapt treatment plan based on manual contouring







Source: G. Sharp

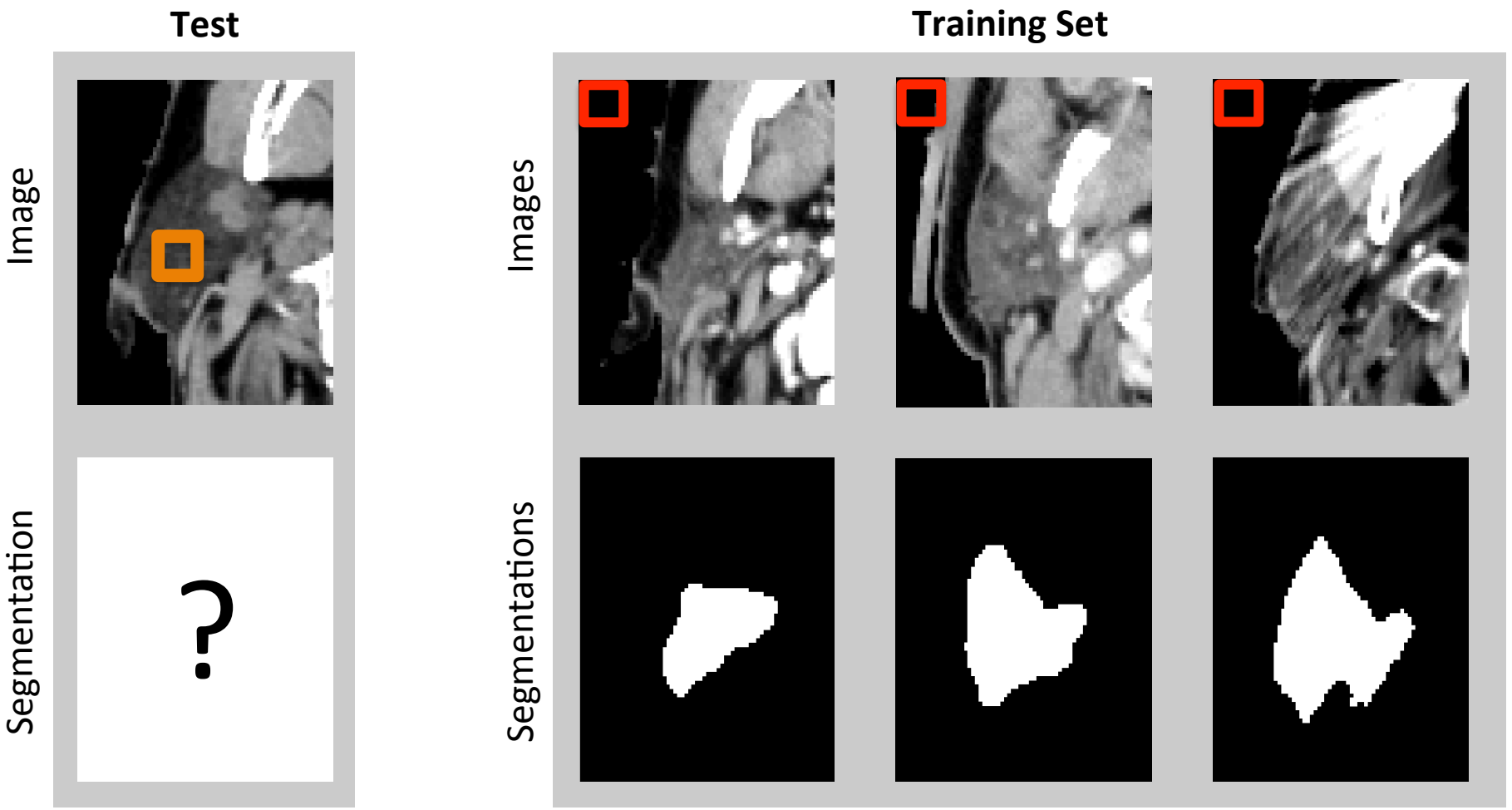
Related Work

- **Atlas-based segmentation**
  - Most approaches from the head and neck segmentation challenge, MICCAI 2010
  - Fritscher et al., 2014: Combination with statistical appearance models and geodesic active contours
- **Patch-based segmentation**
  - Wachinger et al., 2013: Contour-driven refinement with Gaussian processes

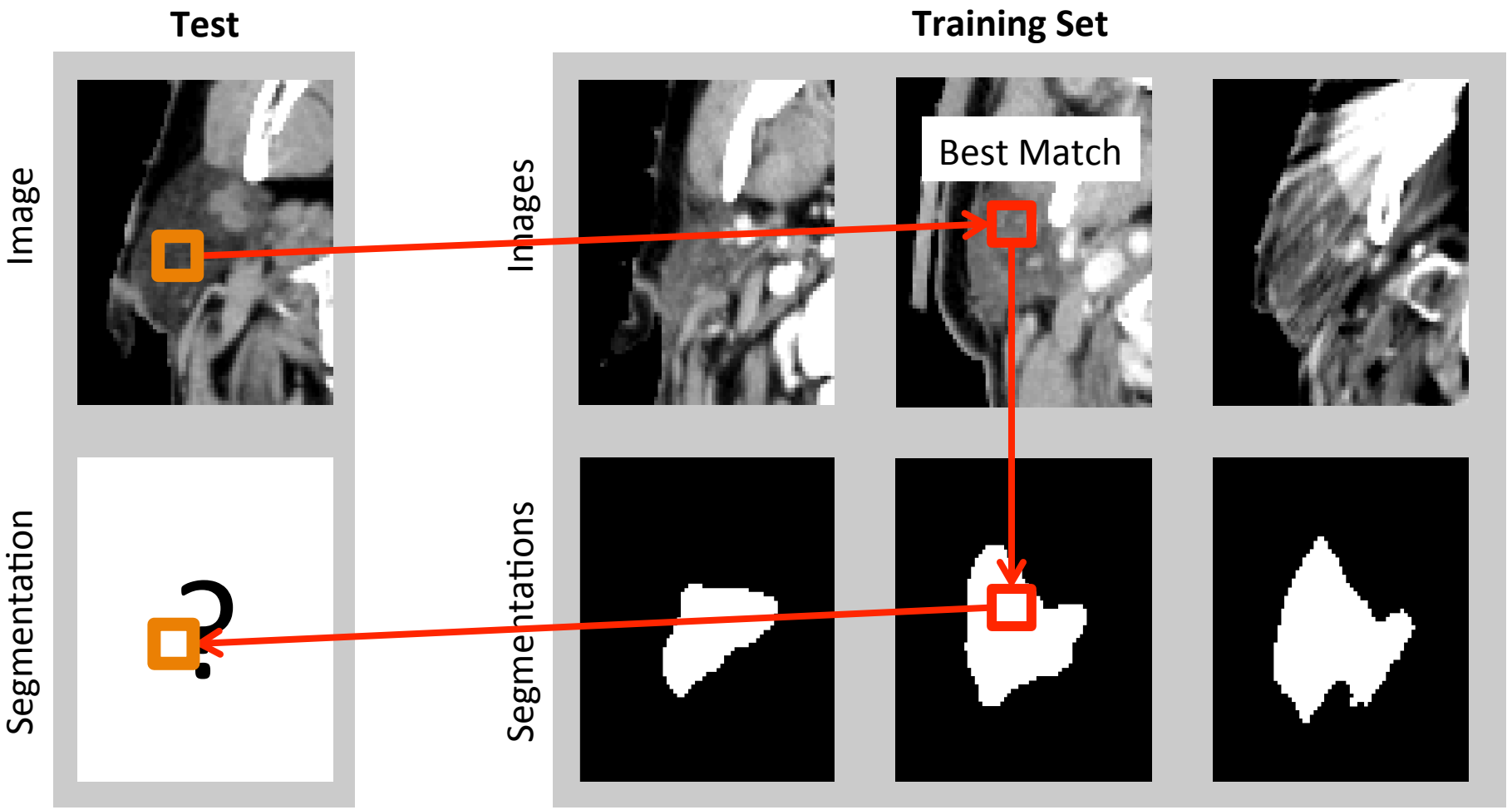
Method

- Descriptor-based segmentation
  - Patches
  - Features
  - Location
- Comparison of a large number of features
- Approximate nearest neighbor search

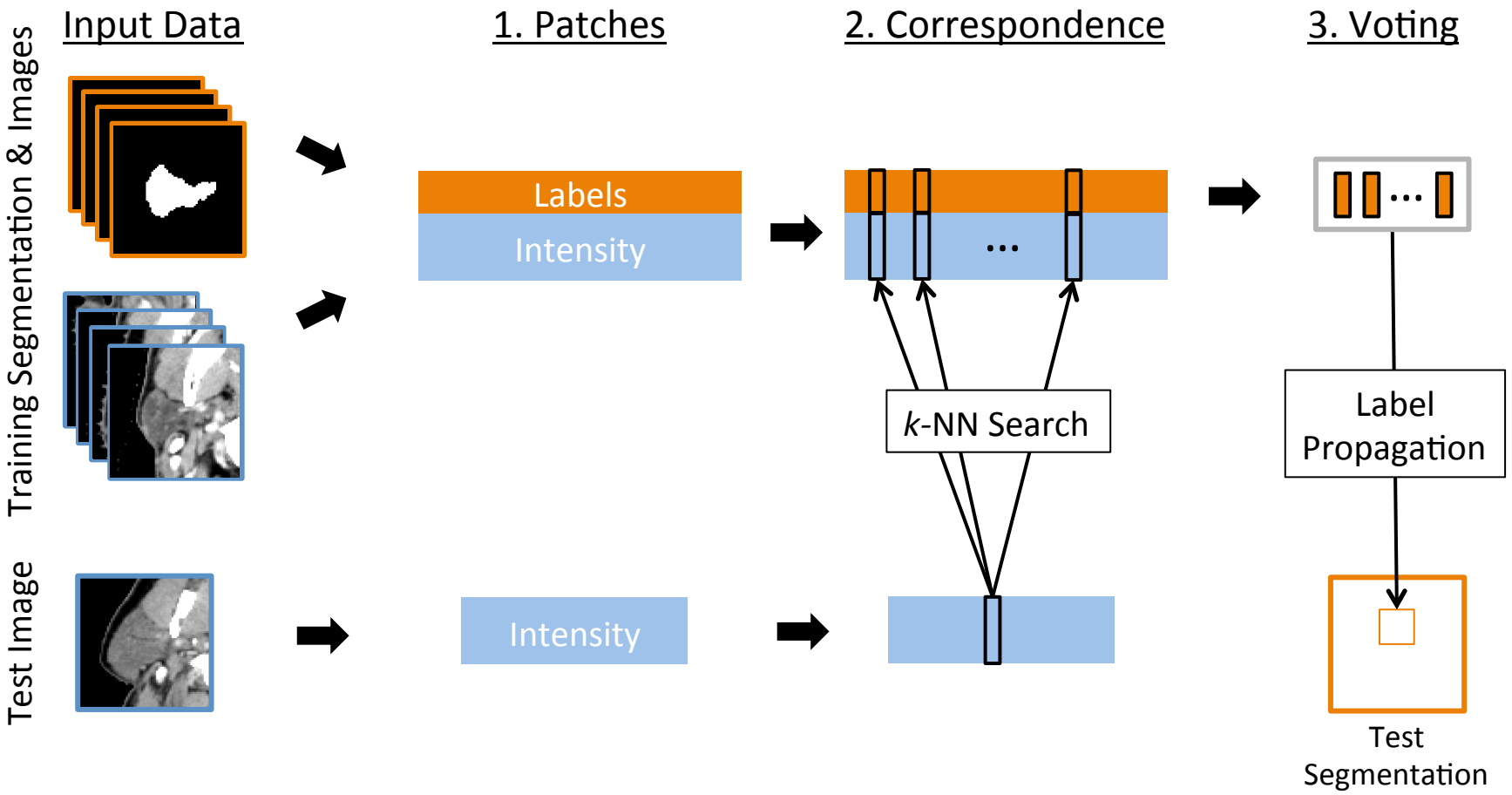
Patch-Based Segmentation:
Non-Local Means (Buades et al., 2005)



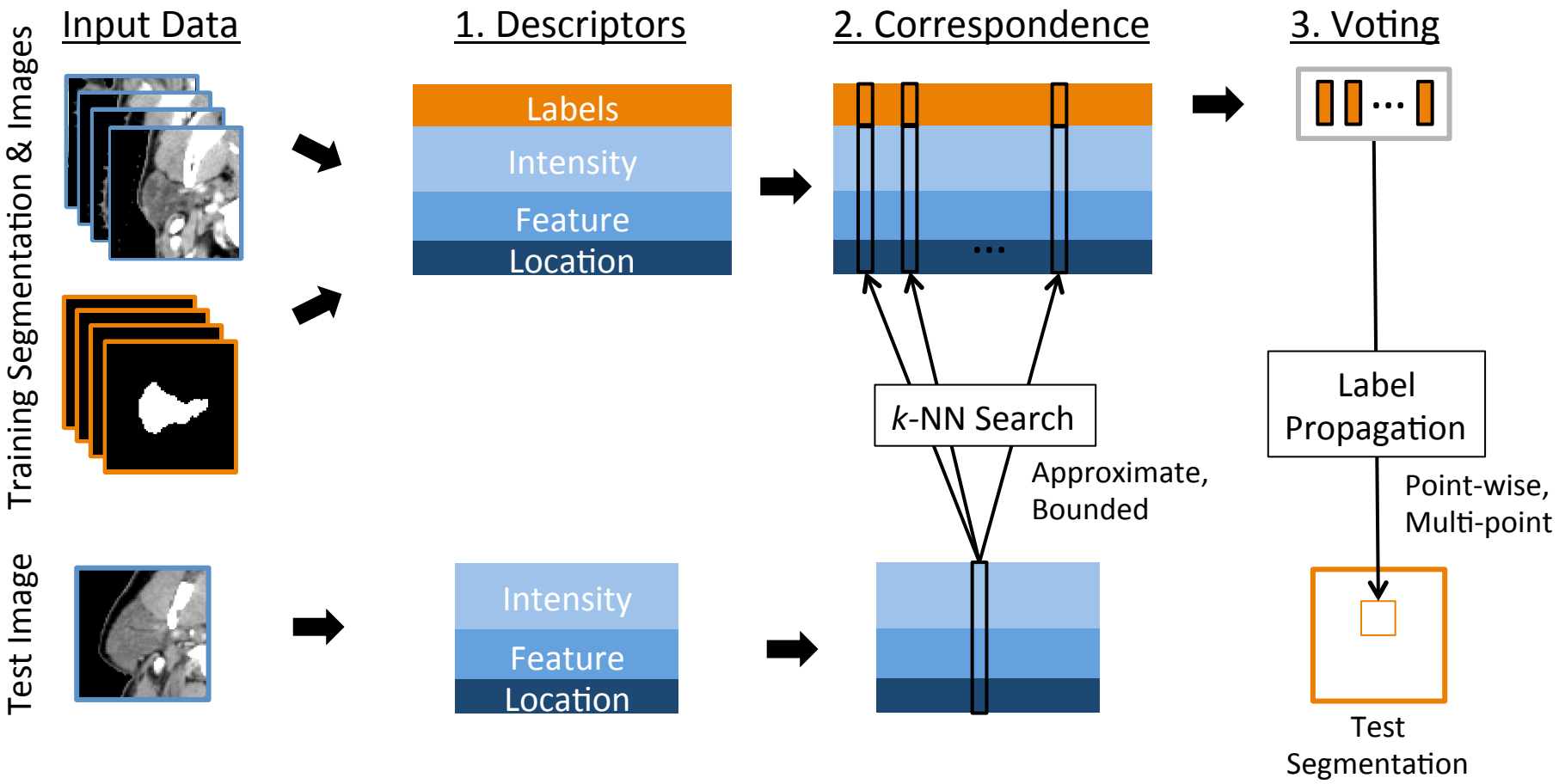
Patch-Based Segmentation:
Non-Local Means (Buades et al., 2005)



Patch-Based Segmentation



Descriptor-Based Segmentation



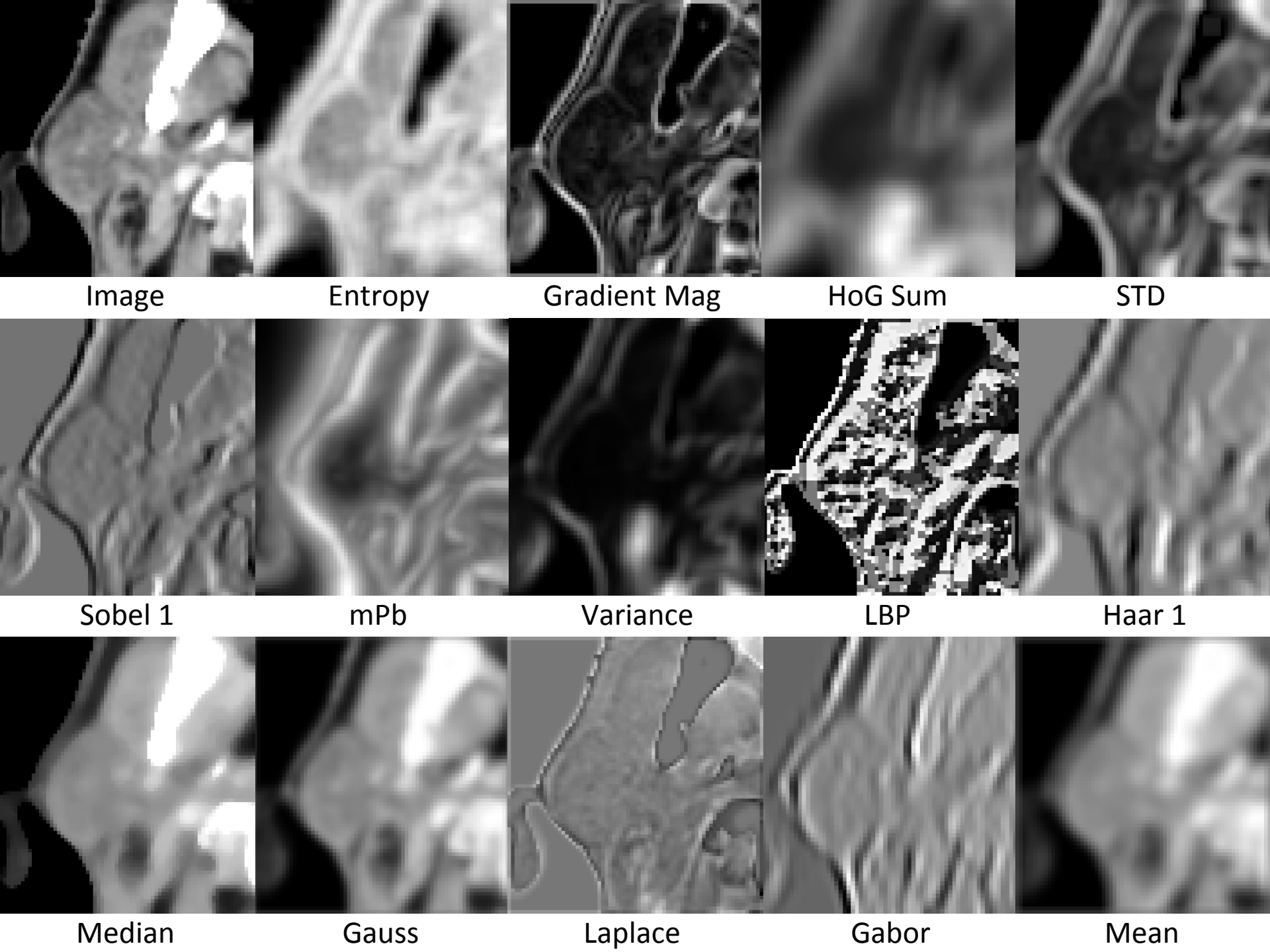


Image
Entropy
Gradient Mag
HoG Sum
STD
Sobel 1
mPb
Variance
LBP
Haar 1
Median
Gauss
Laplace
Gabor
Mean

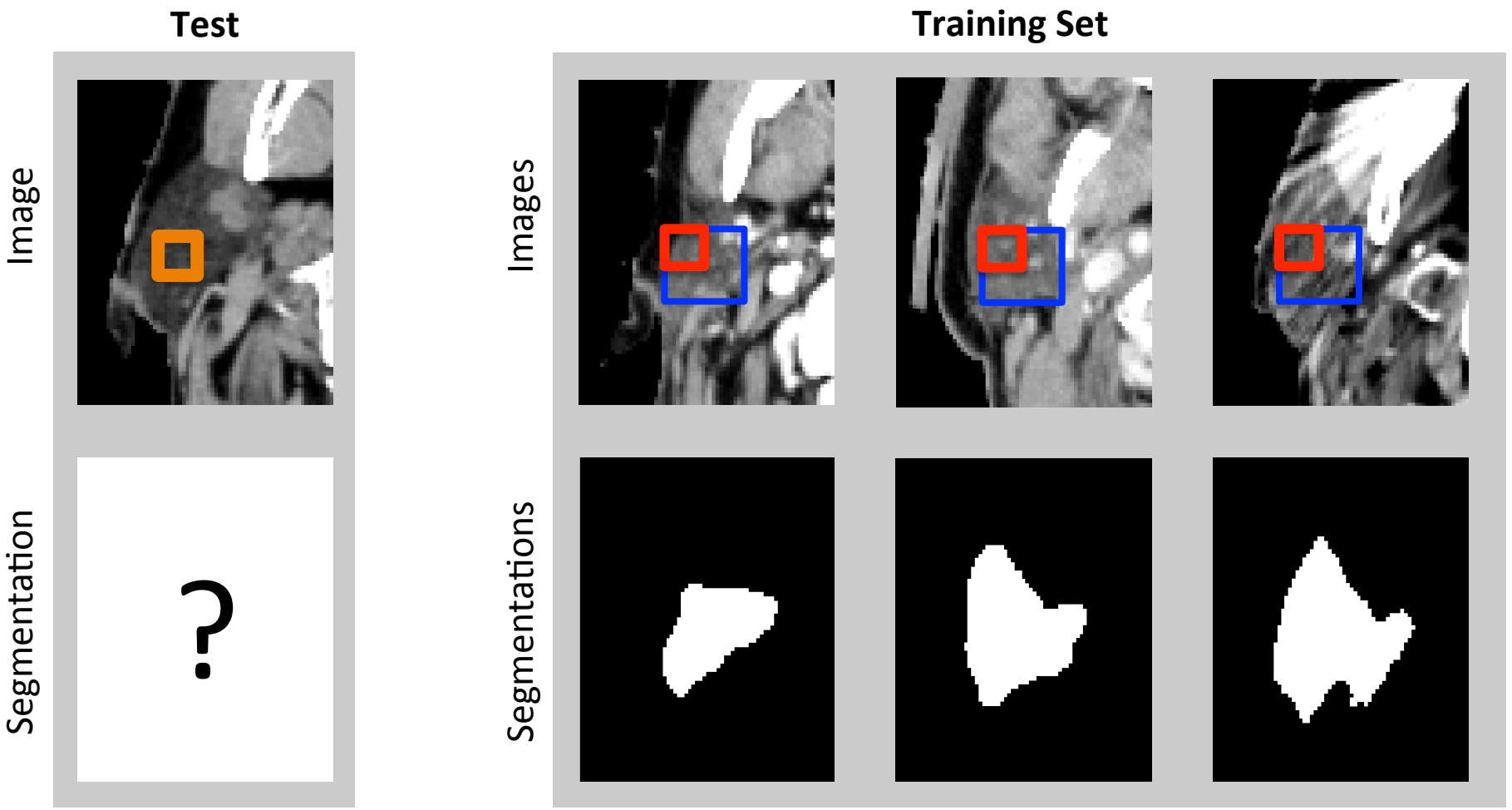
Nearest Neighbor Search

$$\arg \min_{D' \in \mathcal{D}} \|D - D'\|_2$$

Computationally complex for large $\mathcal{D}$

– Bounded non-local means

Bounded Non-Local Means
(Coupe et al., Rousseau et al., 2011)



Nearest Neighbor Search

$$\arg \min_{D' \in \mathcal{D}} \|D - D'\|_2$$

Computationally complex for large $\mathcal{D}$

- Bounded non-local means
  - Location information implicit (hard constraint)
  - Contrary to “non-local” idea
- Approximate NN search
  - Location information explicit (soft constraint)
  - Randomized kd-trees (Muja, Lowe, PAMI, 2014)

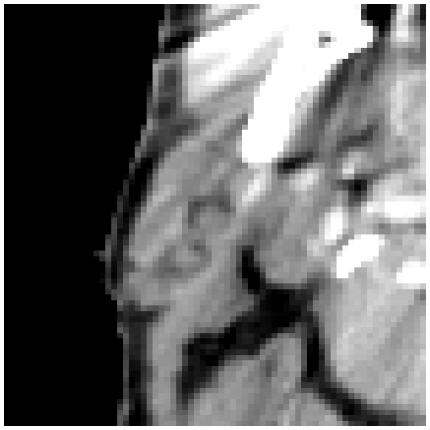
Experiments

- 18 CT head and neck images
  - Leave-one-out segmentation procedure
  - Intensity clipping at -100 and 150 HU
- Standard configuration
  - Anisotropic patches: 9 x 9 x 5 voxels
  - *k*=10 nearest neighbors
  - Multi-point voting

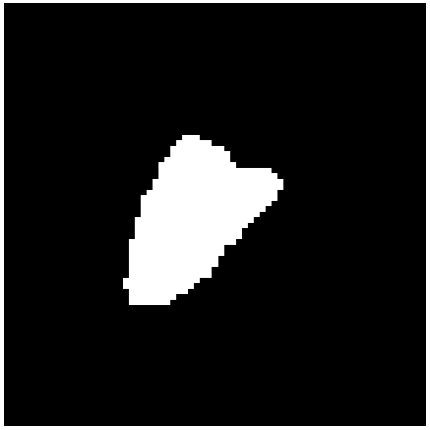
Importance of Location in NLM

- Segmentation results with Dice
- Patches w and w/o location
- Multi-point and point-wise voting

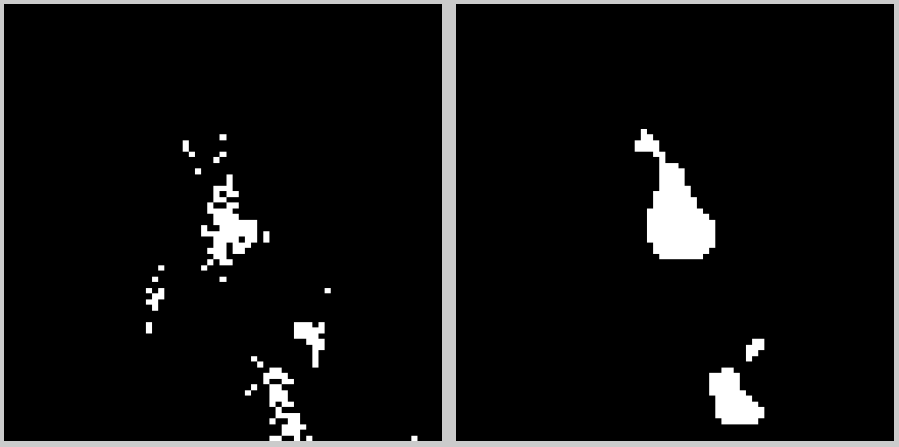
Image



Segmentation



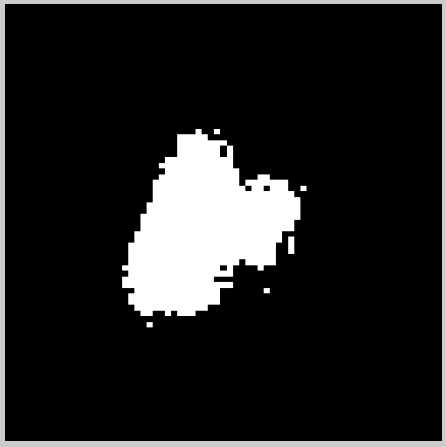
Without Location Information



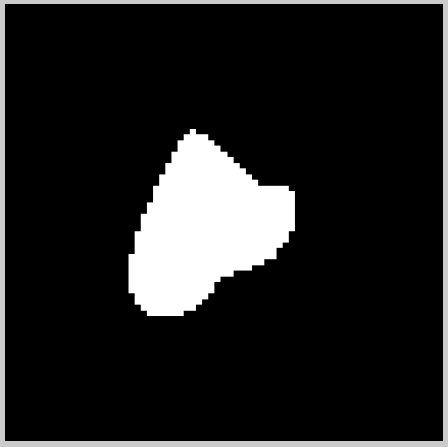
Point-wise: 0.14

Multi-point: 0.18

With Location Information



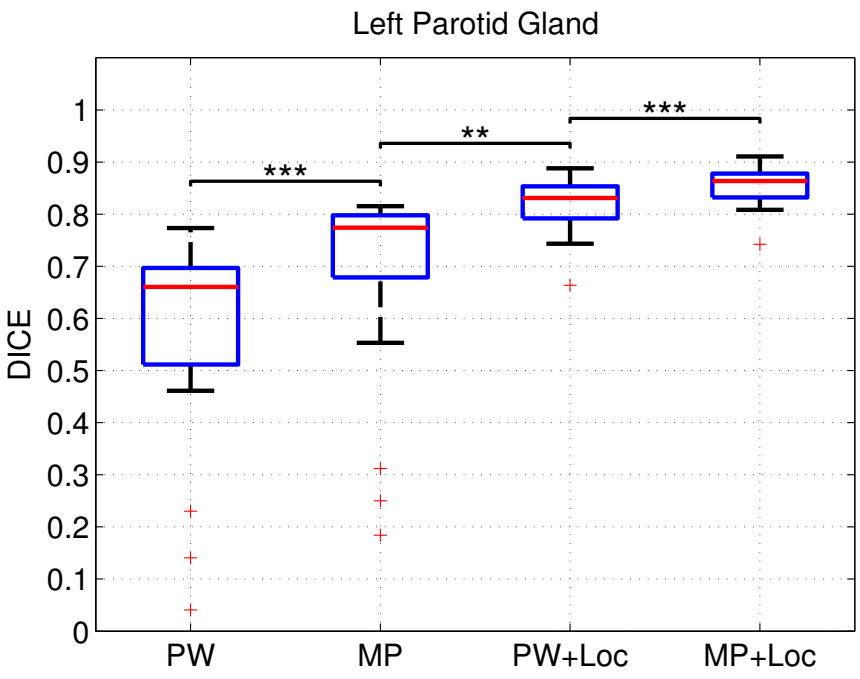
Point-wise: 0.83

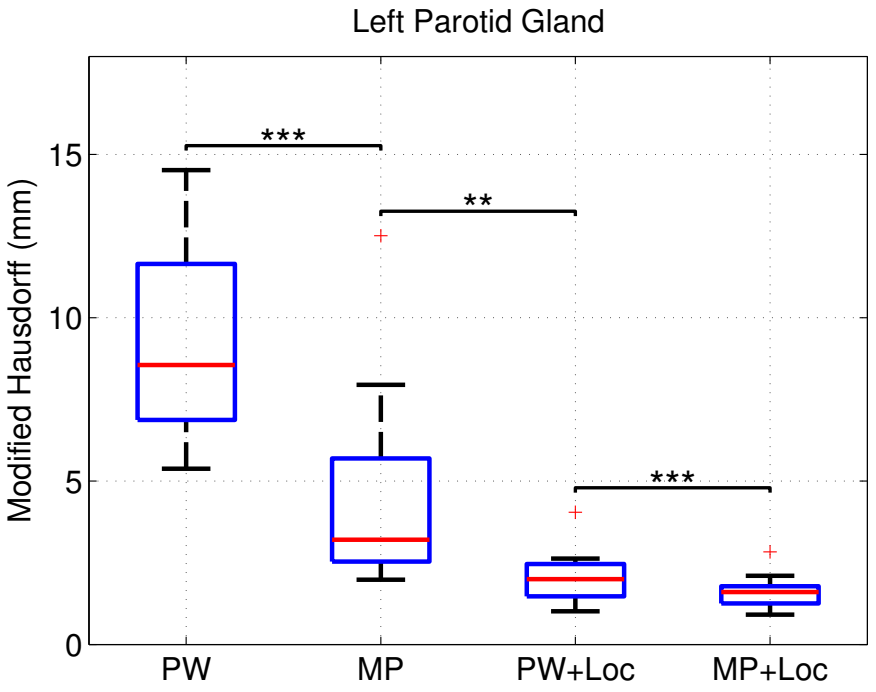


Multi-Point: 0.87

Importance of Location in NLM

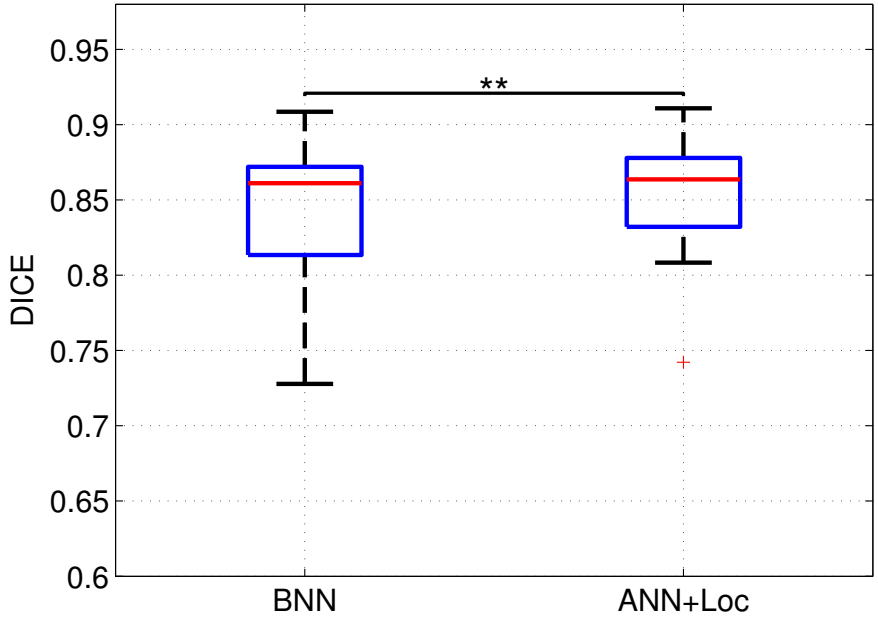
- Patches with and without location information (Loc)
- Point-wise (PW) and multi-point (MP) voting
- Dice overlap score and modified Hausdorff distance





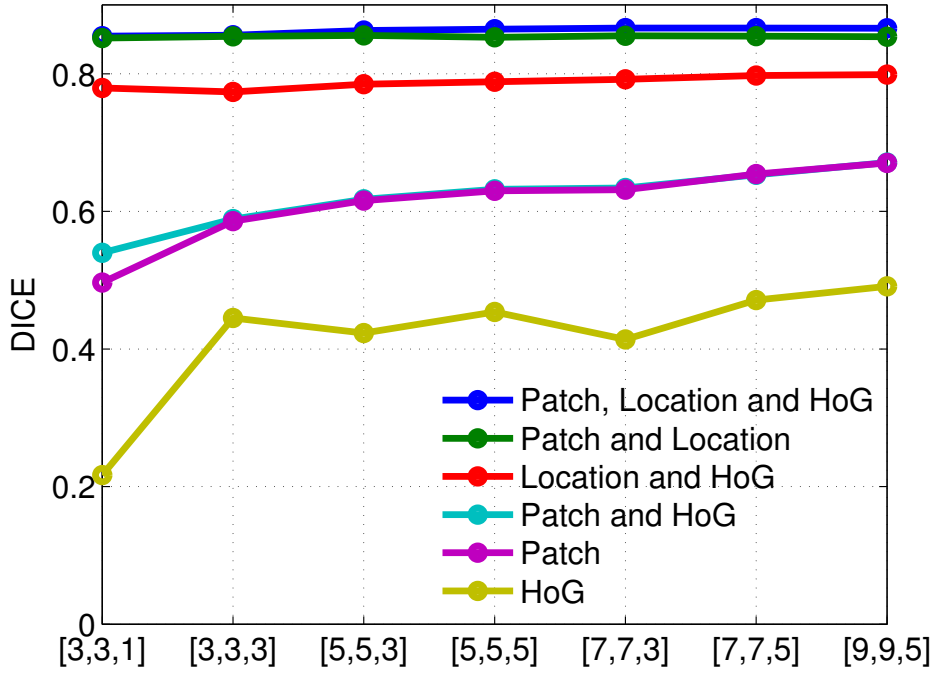
Improvement of Soft Location Constraint

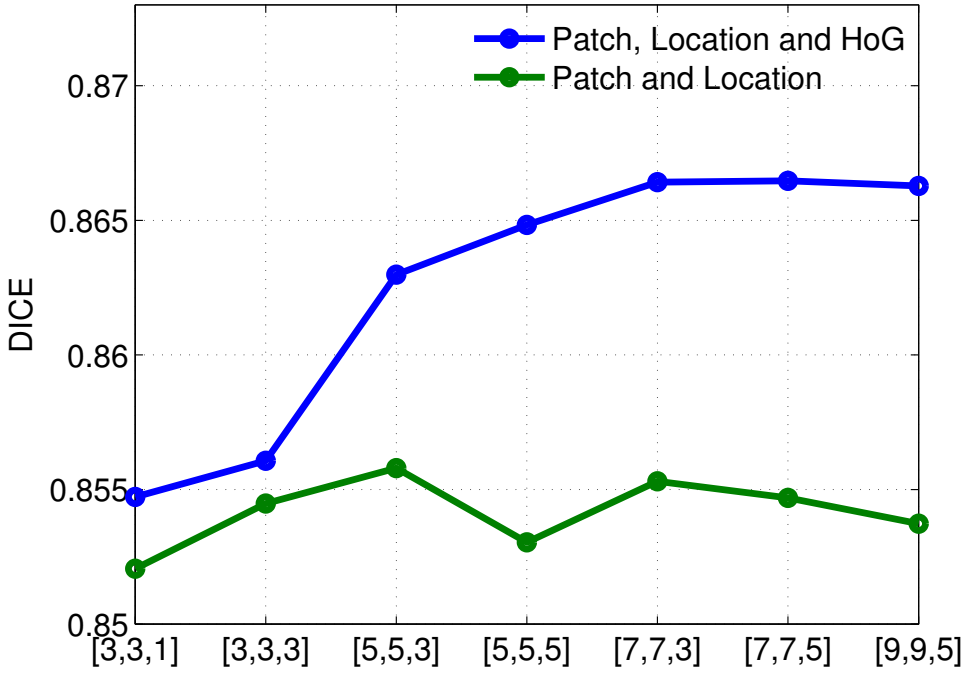
- Comparison of
  - bounded NN search w/o location (BNN)
  - approximate NN search w/ location (ANN+Loc)



Importance of Features and Location

- Mean dice for
  - Different compositions of the descriptor
  - Patch sizes





Comparison among features

- Left parotid gland

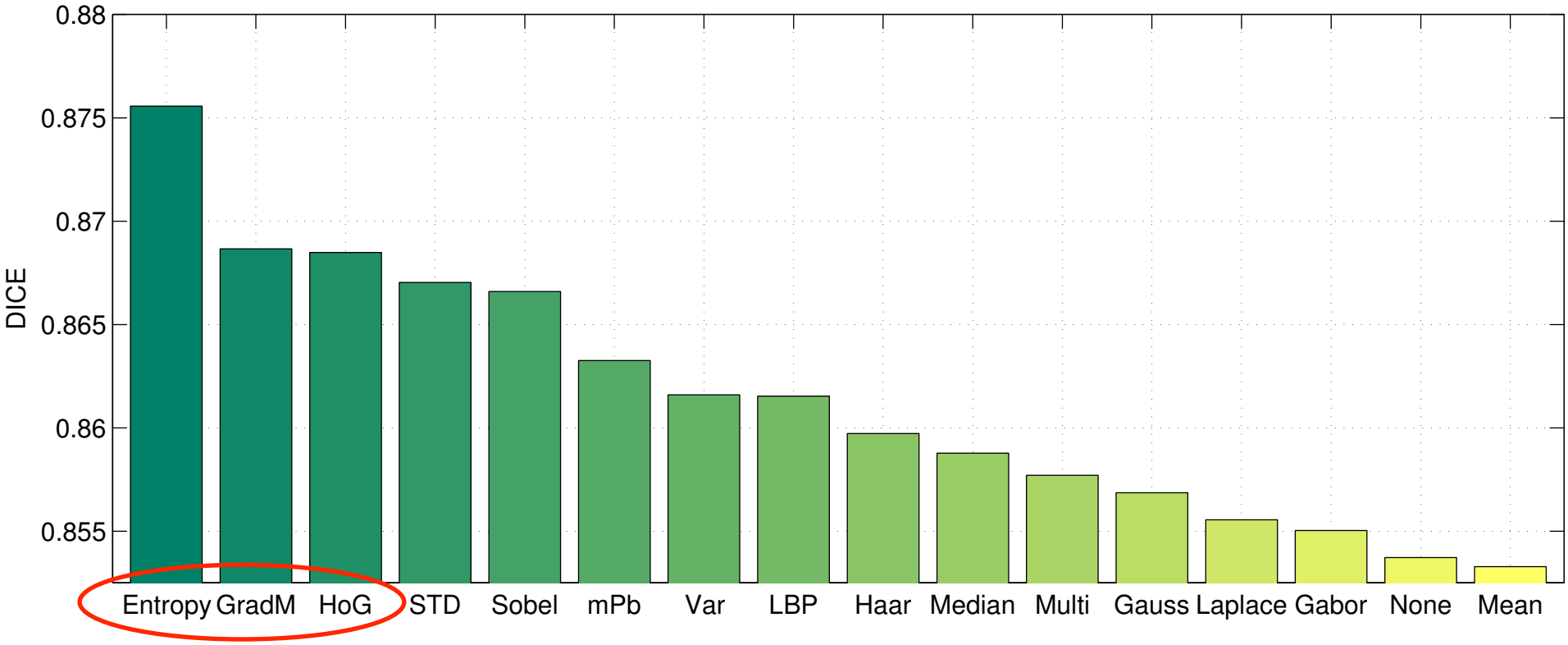


Image contours / gradients

Conclusion

- Importance of features and location in descriptor-based segmentation
- Best results for features that complement patch
- Soft location constraints improve over hard cut-offs of bounded search
- Approximate NN search to handle computational complexity

Thank you!

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