Fast Automatic Vertebrae Detection and Localization in Pathological CT Scans – A Deep Learning Approach

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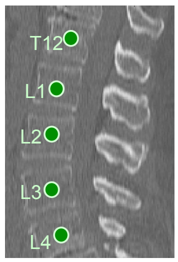
Introduction

Overview

- Input: 3-dimensional CT image
- Detection:
  - Which vertebrae are present?
  - Answer: T12 to L4
- Localization:
  - Where is the centroid of each vertebral body? Answer



Clinical Impact

- Necessary for many computer-aided systems.
- Required for automatic mining of archived clinical data.
- Pre-processing step for other clinical tasks.
- Key requirement: Processing data in interactive time.

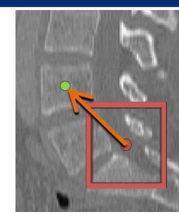
Challenges

- Restrictions in the field of view.
- Repetitive nature of the spinal column.
- High inter-subject variability.
- Image artifacts caused by surgical implants.

Method

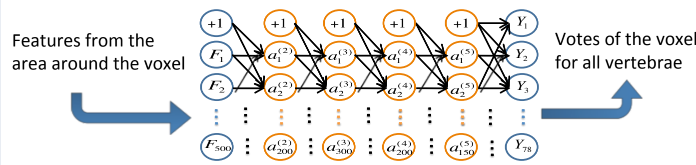
Problem Parameterization

- Each voxel votes for its relative distance to the centroid of a specific vertebral body[1].
- The centroid of the votes of all voxels is our prediction for the location of that vertebra[1].



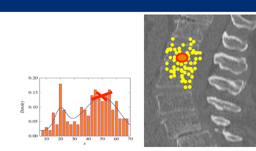
Deep Neural Networks

- Deep neural networks are trained using stochastic gradient descent and layerwise pre-training.



Kernel Density Estimation

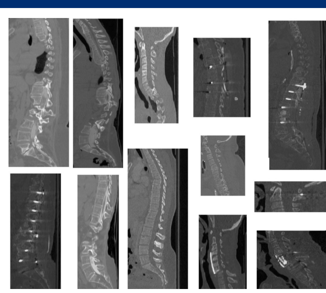
- Kernel density estimation[3] is used for estimating the centroid of the votes of all voxels.



Materials

Dataset

- 224 3D CT scans.
- Publicly-available.
- Mostly pathological cases.
- From different regions of the spine.
- Includes post-operative images.
- Includes surgical implants.



Results

Comparison to State-of-the-art

- Two-fold cross-validation on a public dataset.
- Same train and test sets as used in previous works.
- No assumptions made about field-of-view.

	Detection accuracy	Localization mean error	Computational time
Ours	**96.0%**	18.2 mm	**3 seconds**
[Glocker 2013][2]	93.9%	**12.4 mm**	1 minute
[Glocker 2012][1]	- - -	20.9 mm	2 minutes

References

[1] B. Glocker, J. Feulner, A. Criminisi, D. Haynor, and E. Konukoglu, "Automatic localization and identification of vertebrae in arbitrary field-of-view CT scans," in *MICCAI*, pages 590–598, Springer, *2012*.
[2] B. Glocker, D. Zikic, E. Konukoglu, D. Haynor, and A. Criminisi, "Vertebrae localization in pathological spine CT via dense classification from sparse annotations," in *MICCAI,* pages 262-270 , Springer, *2013*.
[3] Z. Botev, et al., "Kernel density estimation via diffusion," In *The Annals of Statistics*, 38(5):2916–2957, 2010.

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