Vertebrae Localization in Pathological Spine CT via Dense Classification from Sparse Annotation

Ben Glocker[1], Darko Zikic[1] , Ender Konukoglu[2], David R. Haynor[3], Antonio Criminisi[1]

[1]Microsoft Research Cambridge, UK [2]Martinos Center, MGH, Harvard Medical School, USA [3]University of Washington, Seattle, USA

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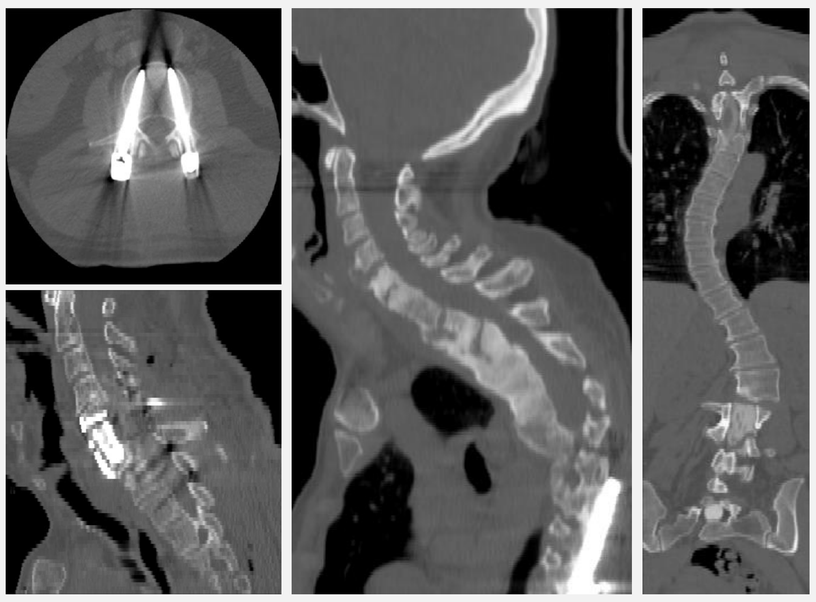
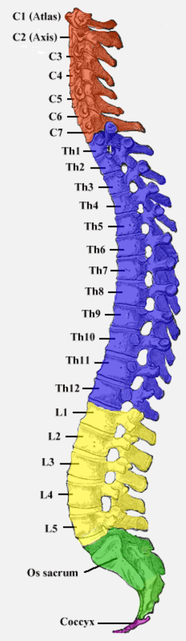
Task: Locate and Name Vertebrae



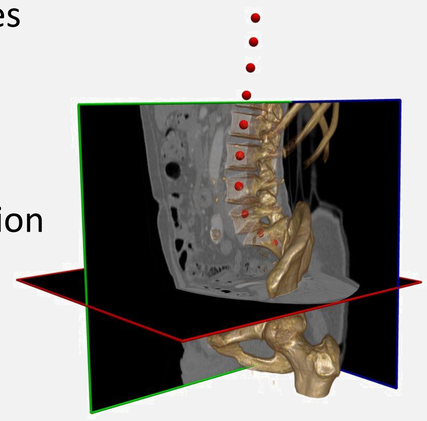


Motivation: Patient-specific coordinate system

- longitudinal registration of pre- and post-operative scans
- initializing vertebral body segmentation methods
- image-guided assessment of surgical outcomes
- shape & population analysis

Challenges

- small field-of-view, lack of contextual information
- low resolution, image noise
- presence of pathologies
- image artifacts due to surgical implants

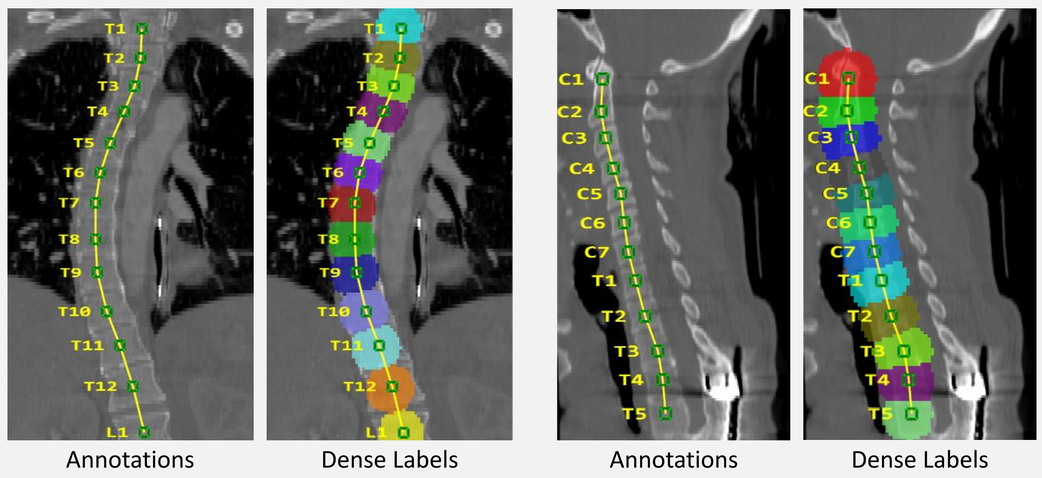


Localization via Dense Classification

› Dense Labels from Sparse Annotations

Generate training data for learning a dense classifier

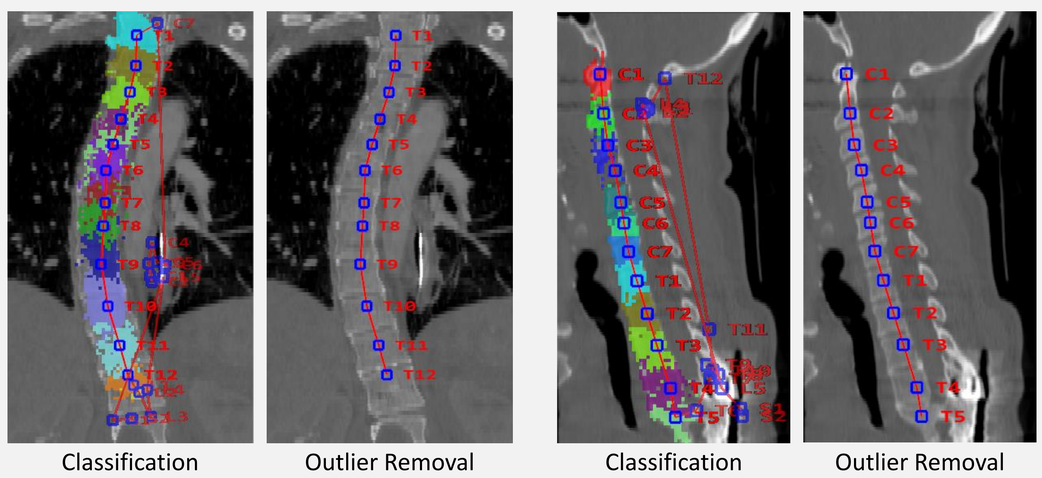
Training



› Centroid Estimation from Dense Classification

Voxel-wise classification, mean shift, and outlier removal

Testing



Quantitative Evaluation

Two Clinical Datasets

Normal CT

- **200 CT scans**, mostly trauma patients
- slice distances between [0.5, 6.5]mm
- number of slices between [51, 2058]
- from only 4 vertebrae up to whole-body scans

Spine CT

- **224 CT scans**, spine patients
- pre- and post-operative scans
- limited view, 5-15 visible vertebrae
- include high-grade scoliosis, kyphosis, fractures, implants

Experimental Setup

- 2-fold cross-validation (50/50% train-test split)
- 20 trees, depth 24, minimum 8 examples
- 2000 random features with 200 features tested per node
- include only image points in the HU range of spinal structures

Computational Efficiency

- Intel Xeon 2.27GHz, 12 GB RAM, C# implementation
- **Localization of all vertebrae in 512^2x200 images takes 1 minute**

Localization Errors & Identification Rates

Method		Regression Forests + HMM [Glocker et al. 2011]				Proposed Approach			
Data	Region	Median	Mean	Std	Id.Rates	Median	Mean	Std	Id.Rates
Normal CT	All	**5.4**	**9.7**	**11.2**	**80%**	7.6	11.5	14.1	76%
	Cervical	6.5	8.2	6.1	73%	**6.3**	**7.7**	**4.4**	**78%**
	Thoracic	**5.5**	**9.9**	**10.8**	**77%**	8.7	12.4	11.6	67%
	Lumbar	**5.3**	**9.4**	**12.0**	**86%**	6.6	10.6	16.9	**86%**
Spine CT	All	14.8	20.9	20.0	51%	**8.8**	**12.4**	**11.2**	**70%**
	Cervical	11.5	17.0	17.7	54%	**5.9**	**7.0**	**4.7**	**80%**
	Thoracic	12.7	19.0	20.5	56%	**9.8**	**13.8**	**11.8**	**62%**
	Lumbar	23.2	26.6	19.7	42%	**10.2**	**14.3**	**12.3**	**75%**

Spine CT dataset available on
http://research.microsoft.com/medimaging

Visual Examples