Intervertebral Disc Segmentation in less than 3 s Using Mathematical Morphology

Edwin Carlinet, Thierry Géraud

EPITA Research and Development Laboratory (LRDE), France

firstname.lastname@lrde.epita.fr

At a glance

Problem:

- we want to segment intervertebral discs without using CNN...
- ...and we want our method to be fast!

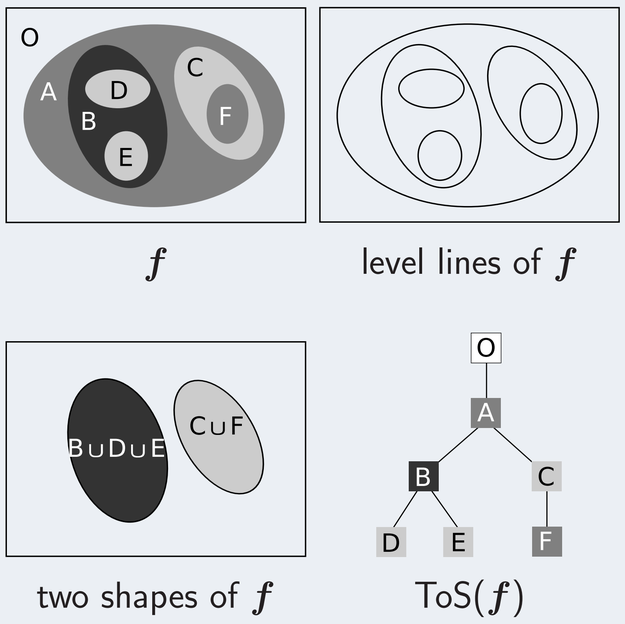
Why our approach is interesting:

- it is lightweight and simple

Conclusion:

- the morphological tree of shapes is a very useful structure [1, 2]
- mathematical morphology rocks [3, 4]
- we do not rely on parallelization [5]... think about .5 s per volume
- perspective: use the *multivariate tree of shapes* [6]

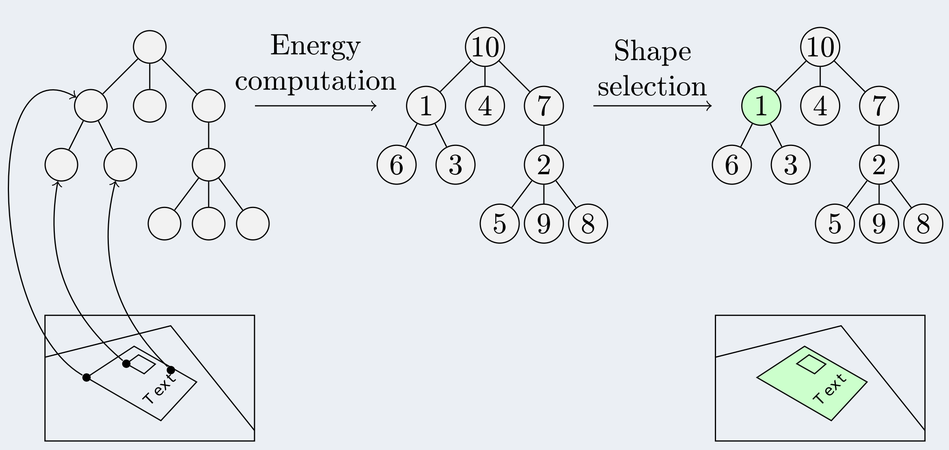
Morphological tree of shapes (ToS)



f | level lines of f

two shapes of f | ToS(f)

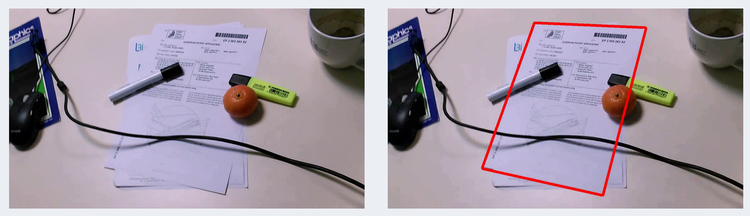
Tree-based object detection



1. Compute the tree of shapes
2. Valuate an energy adapted to the object(s) to detect
3. Retrieve the shape(s) with minimal energy

Illustration:

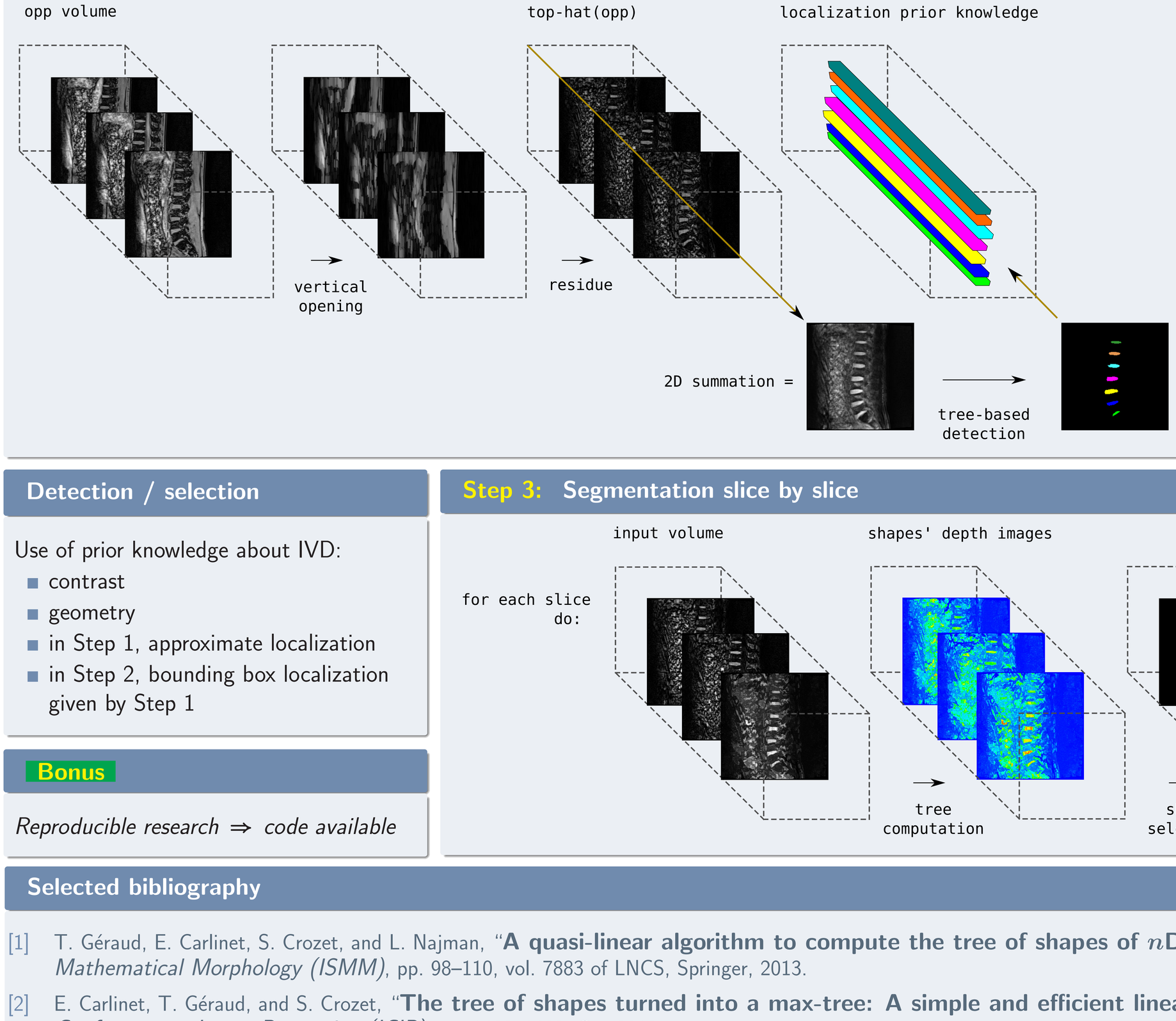
Smartphone document capture competition (SmartDoc) at the Intl. Conf. on Document Analysis and Recognition (ICDAR) 2015



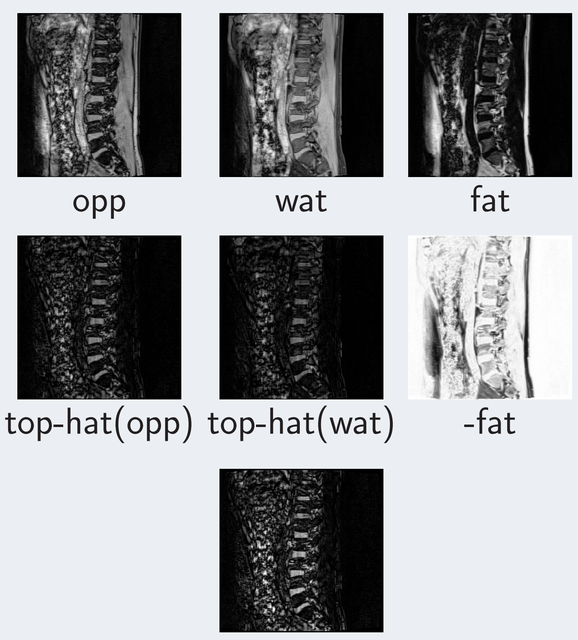
input | selection

(winning method!)

Step 1: Extracting a prior knowledge about discs localization from a volume



Step 2: Create a 3D input



opp | wat | fat

top-hat(opp) | top-hat(wat) | -fat

input = top-hat(opp) + top-hat(wat) - fat

Detection / selection

Use of prior knowledge about IVD:

- contrast
- geometry
- in Step 1, approximate localization
- in Step 2, bounding box localization given by Step 1

Bonus

Reproducible research ⇒ code available

Step 3: Segmentation slice by slice

Selected bibliography

[1] T. Géraud, E. Carlinet, S. Crozet, and L. Najman, "**A quasi-linear algorithm to compute the tree of shapes of nD images**," in *International Symposium on Mathematical Morphology (ISMM)*, pp. 98–110, vol. 7883 of LNCS, Springer, 2013.

[2] E. Carlinet, T. Géraud, and S. Crozet, "**The tree of shapes turned into a max-tree: A simple and efficient linear algorithm**," in *IEEE International Conference on Image Processing (ICIP)*, pp. 1488–1492, Oct 2018.

[3] P. Soille, **Morphological Image Analysis: Principles and Applications**, 2nd ed., Springer, 2004.

[4] L. Najman and H. Talbot Eds., **Mathematical Morphology—From Theory to Applications**, ISTE Ltd and John Wiley & Sons, 2010.

[5] S. Crozet and T. Géraud, "**A first parallel algorithm to compute the morphological tree of shapes of nD images**," in *IEEE International Conference on Image Processing (ICIP)*, pp. 2933–2937, 2014.

[6] E. Carlinet and T. Géraud, "**MToS: A tree of shapes for multivariate images**," *IEEE Transactions on Image Processing*, vol. 24, num. 12, pp. 5330–5342, 2015.