Fast semi-supervised segmentation of in situ tree color images

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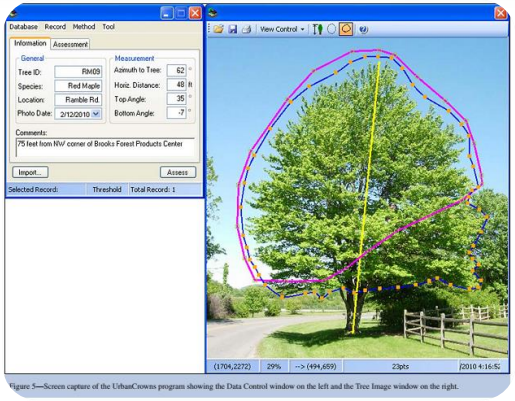
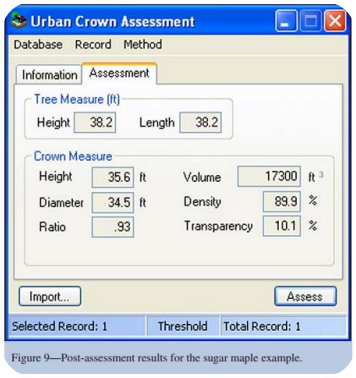
Context

- Regular diagnosis of urban trees to assess their health and… potential risk
- By visually looking to discontinuities in shape and density
- Based on digital photographs taken in situ

Winn, M.F., Araman, P.A., Lee, S.M. "Urban Crowns: an assessment and monitoring tool for urban trees", Gen. Tech. Rep., U.S. Dept. of Agriculture, Forest Service, (2011)





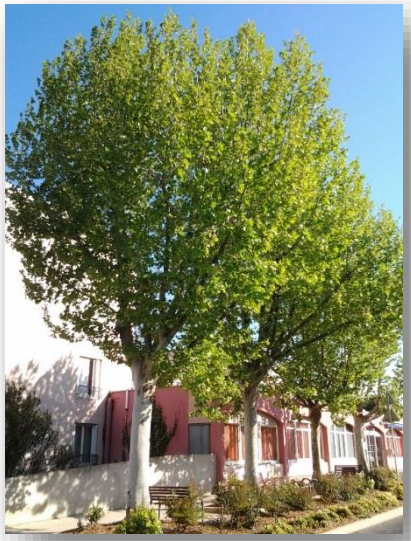
Context

→ Segmenting a tree in natural color images

- Non uniform background

- Lighting problems
- Occulting objects

- Overlap with other trees

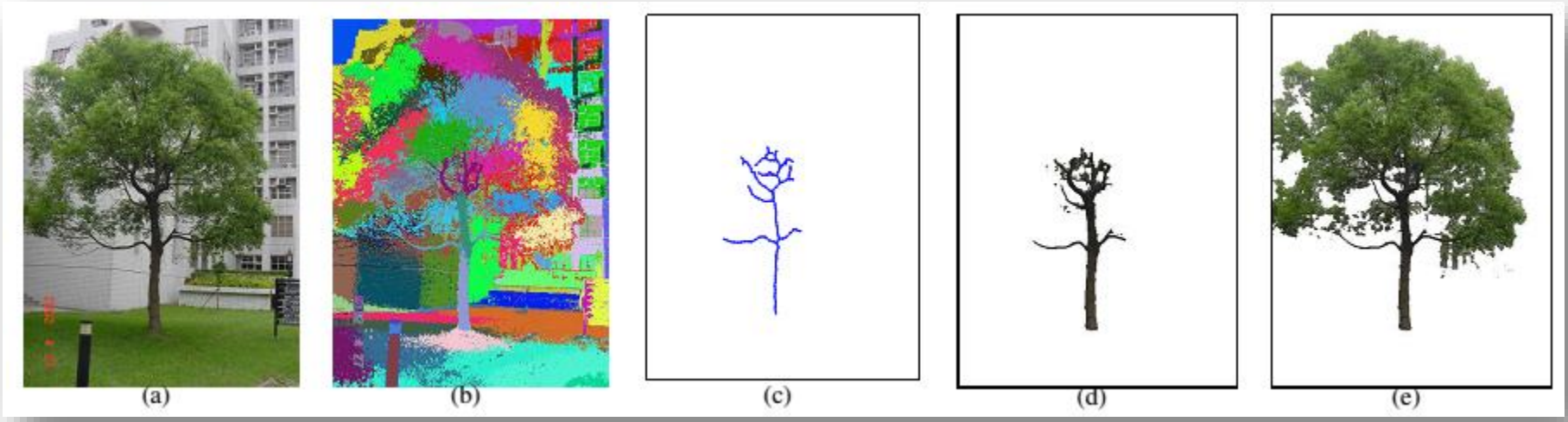


→ On a standard mobile device

Some solutions?

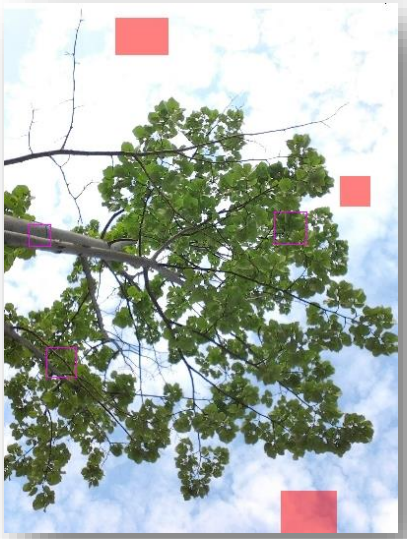
- By making some hypotheses about the tree structure

Too complex scene?



Teng, C.H., Chen Y.S., Hsu, W.H. "Tree segmentation from an Image". In: IAPR Machine Vision Appl., 59-63 (2005)

- By asking the operator to tag different tree parts



Friedland, G., Jantz, K., Rojas, R.: "SIOX: simple interactive object extraction in still images". In: 7th IEEE International Symposium on Multimedia (2005)

Too heterogeneous background?

Proposed method

1. Reduce the color dynamic range with a quick algorithm.

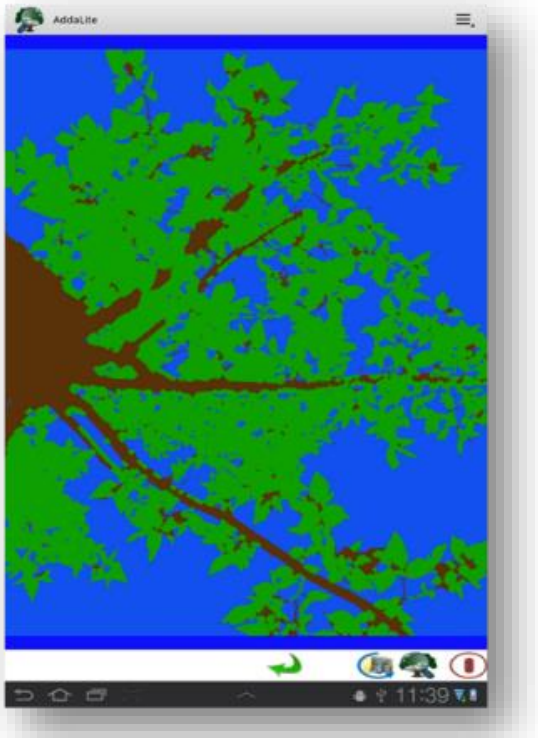
2. The operator quickly and roughly tags some parts of the image which become learning areas (LA) for the labeling process…

   …which will then classify all the pixels of the image.

3. A post-processing will emphasize narrow and thin structures.

→ 3 labels :

- Leaves
- Wood
- Background

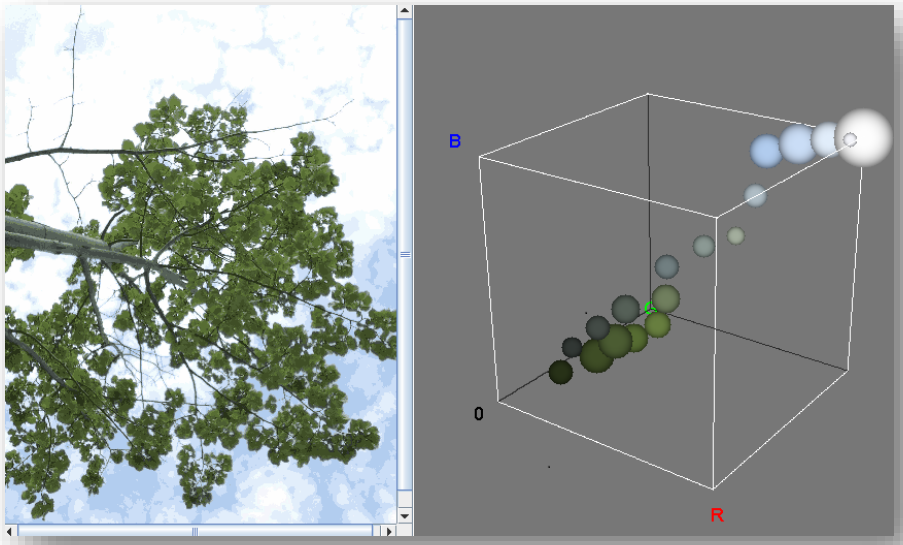


1. Reduction of the color image dynamic range

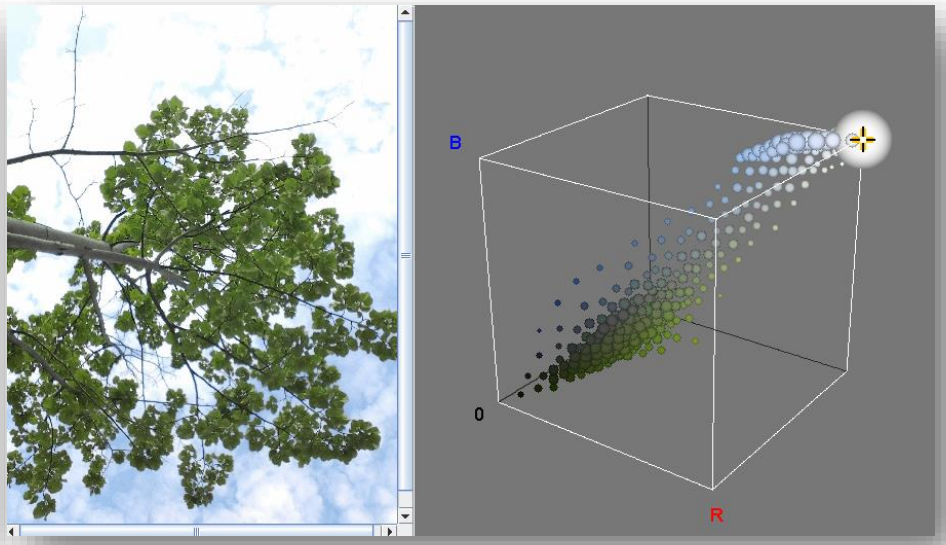
From native 24-bit to 8-bit to reduce complexity

Wu, X. "Color quantization by dynamic programming and principal analysis". In: ACM Transactions on Graphics. 11(4) : 348-372 (1992)

- PCA in the color space
- Recursive decomposition to reach a given number of colors



20 colors



200 colors

(example in RGB color space)

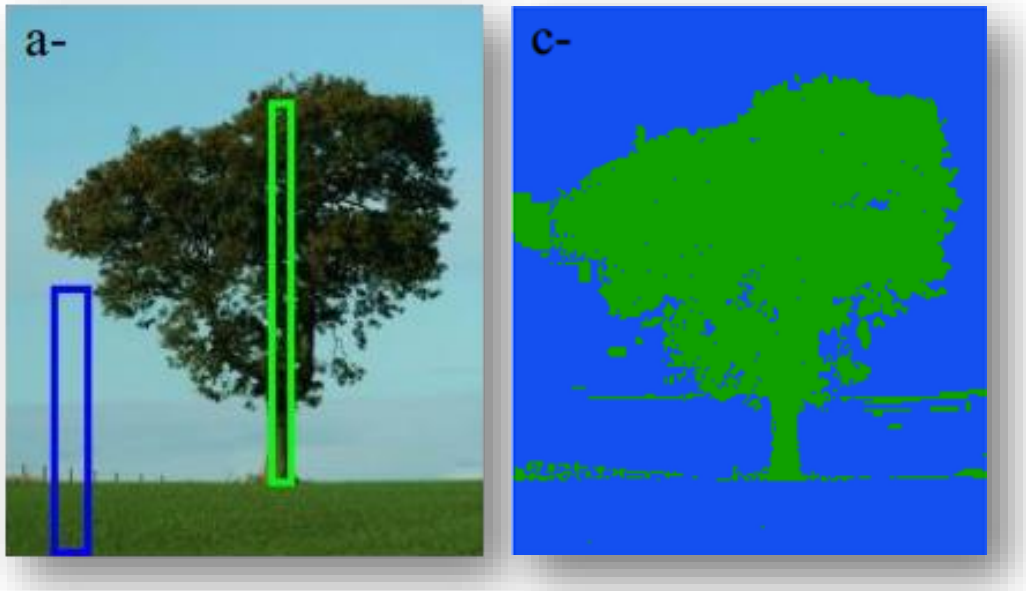
2. Labeling of the image

Strategy A : from the most to the less homogeneous LA

1. *Sort all the LAs w.r.t. to their variance*
2. *Along the LAs*

    i. Assign the corresponding label to all the colors belonging to the LA
    ii. Remove all these labelled colors to the remaining LAs.

3. *Compute new variances of remaining LAs and reorder*



Aberrant labelling caused by the heterogeneity of LA?

2. Labeling of the image

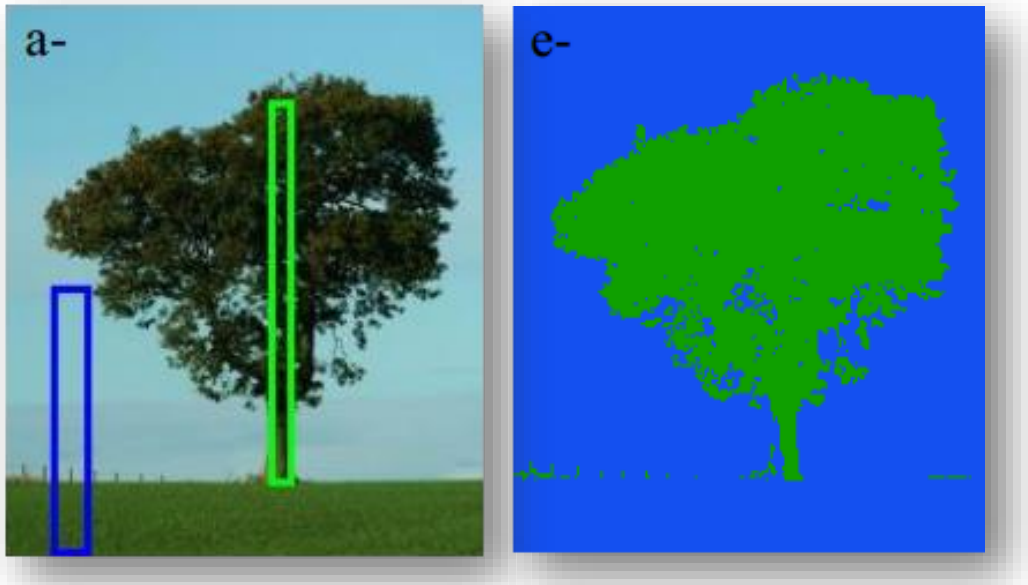
Strategy B : fragmenting heterogeneous LAs

0. *Fragment all the LAs in subLAs by a k-means clustering to be under a maximal variance*

1. *Sort all the subLAs w.r.t. to their variance*

2. *Along the subLAs*
   - *i. For each color of the subLA, compute the distance to the current and already processed subLAs.*
   - *ii. Assign the label corresponding to the subLA with minimal distance*
   - *iii. Remove all these labelled colors to the remaining subLAs*

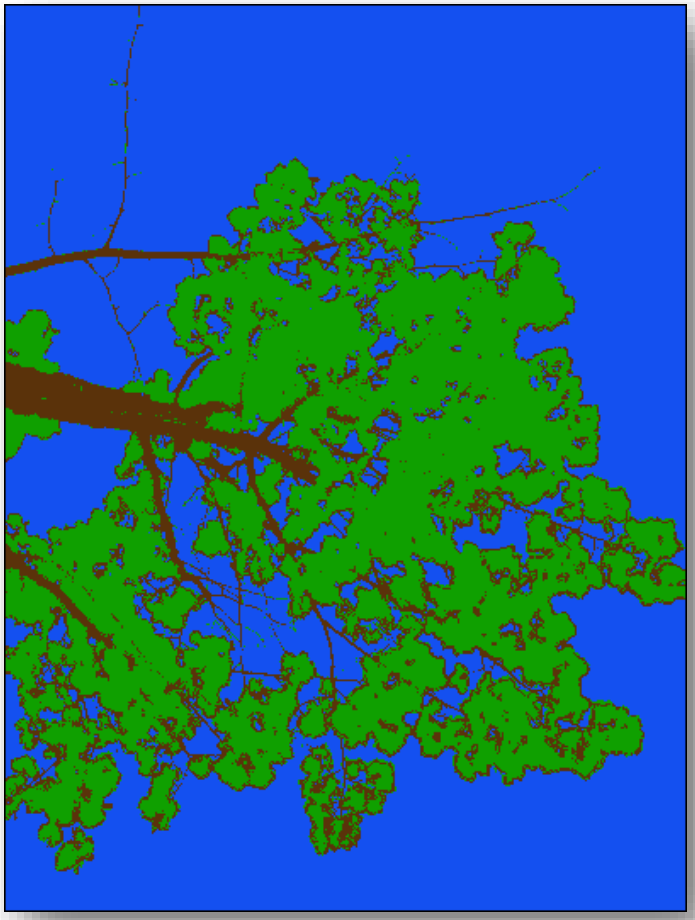
3. *Compute new variances of remaining subLAs and reorder*

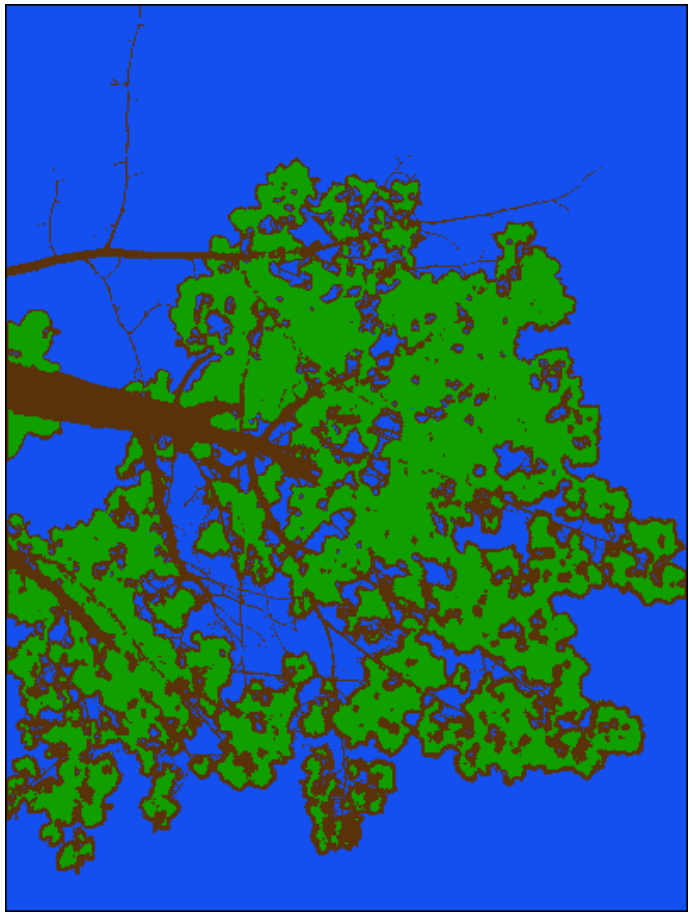


Better results?

Stage 3: post-processing to emphasize narrow and thin structures

- Conditional dilations of “wood” at the expense of “leaves” in order to strengthen branches

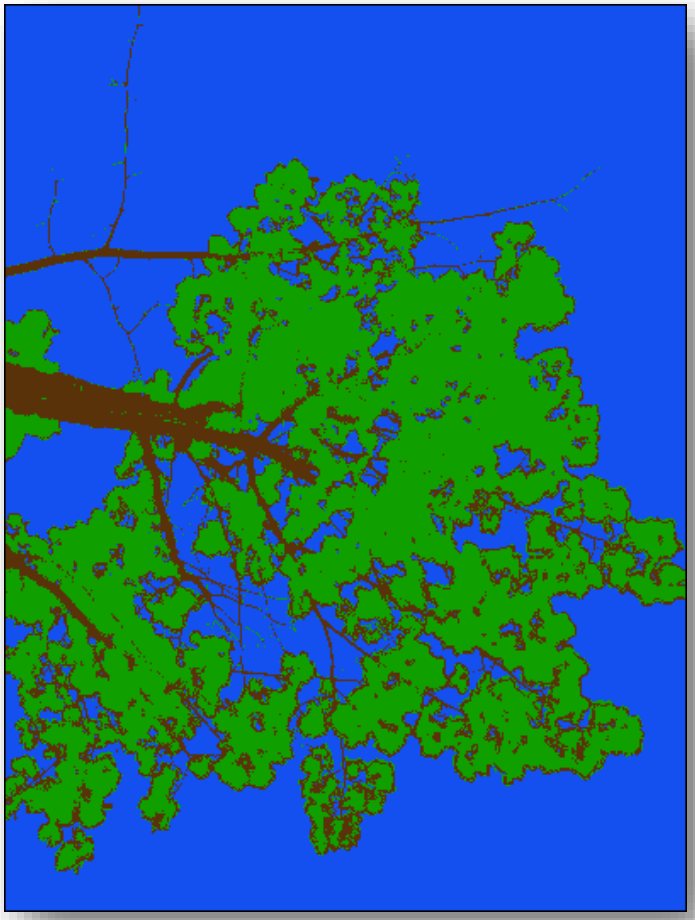


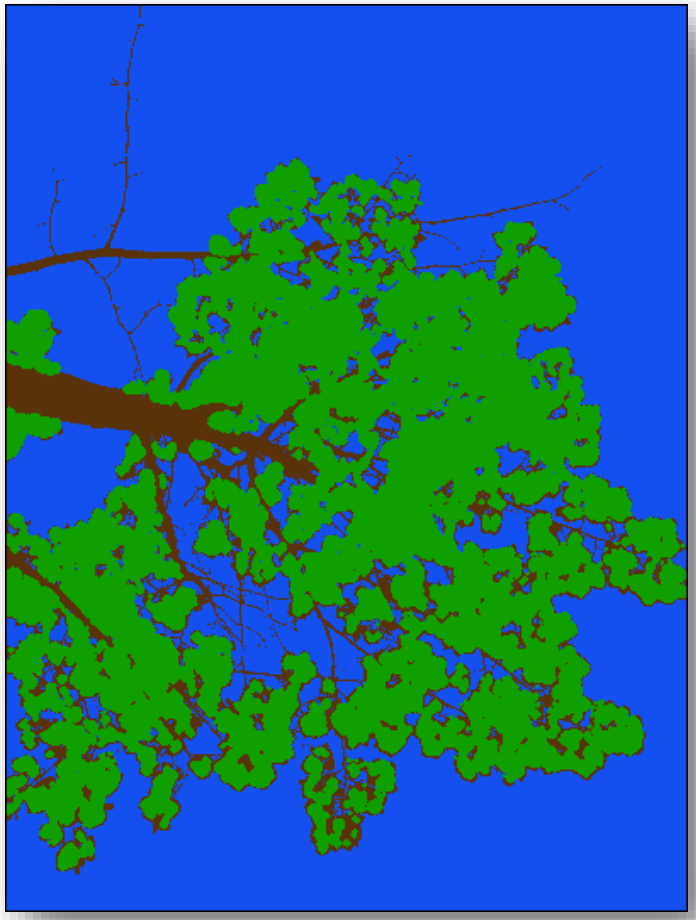


$$\boldsymbol{W_{i+1} = \{p \in W_i\} \cup \{p \in L_i \mid S_{p,w} \not\subset L_i\}} \text{ and } \boldsymbol{L_{i+1} = \{p \in L_i \mid S_{p,w} \subset L_i\}} \text{ with } \boldsymbol{W_0 = W, L_0 = L}$$

Stage 3: post-processing to emphasize narrow and thin structures

- Conditional dilations of “wood” at the expense of “leaves” in order to strengthen branches
- Opposite conditional dilations of “leaves” at the expense of “wood”.





$$W_{i+1} = \{p \in W_i\} \cup \{p \in L_i \mid S_{p,w} \not\subset L_i\} \text{ and } L_{i+1} = \{p \in L_i \mid S_{p,w} \subset L_i\} \text{ with } W_0 = W, L_0 = L$$

$$L_{i+1} = \{p \in L_i\} \cup \{q \in W_i \mid q \in S_{p,w}, p \in L_i\} \text{ and } W_{i+1} = \{p \in W_i \mid p \notin S_{q,w}, q \in L_i\}$$

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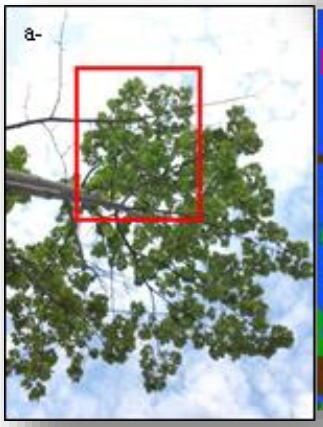
Discussion

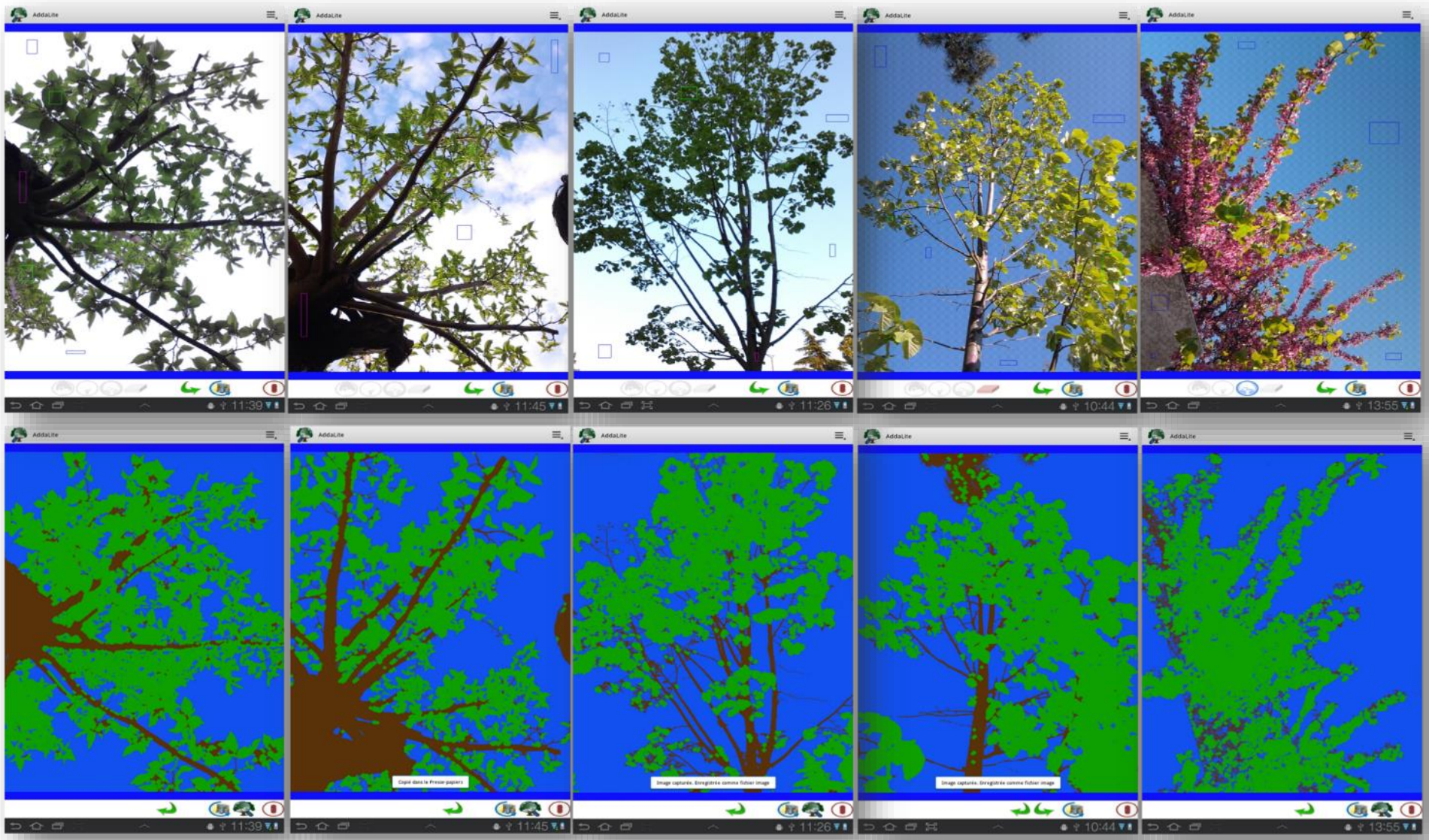
- Sensitivity to the learning areas?
  - BLA= 3 large heterogeneous LAs
  - SLA= 9 small homogeneous LAs
    - → Strategy B for using BLA

- Optimal color system?
  - → L*a*b* better



- Other parameters?
  - ….found experimentally…
  - → Step 1: number of colors=200
  - → Step 2, strategy B, maximal variance for fragmentation=10
  - → Step 3: number of conditional dilations=3

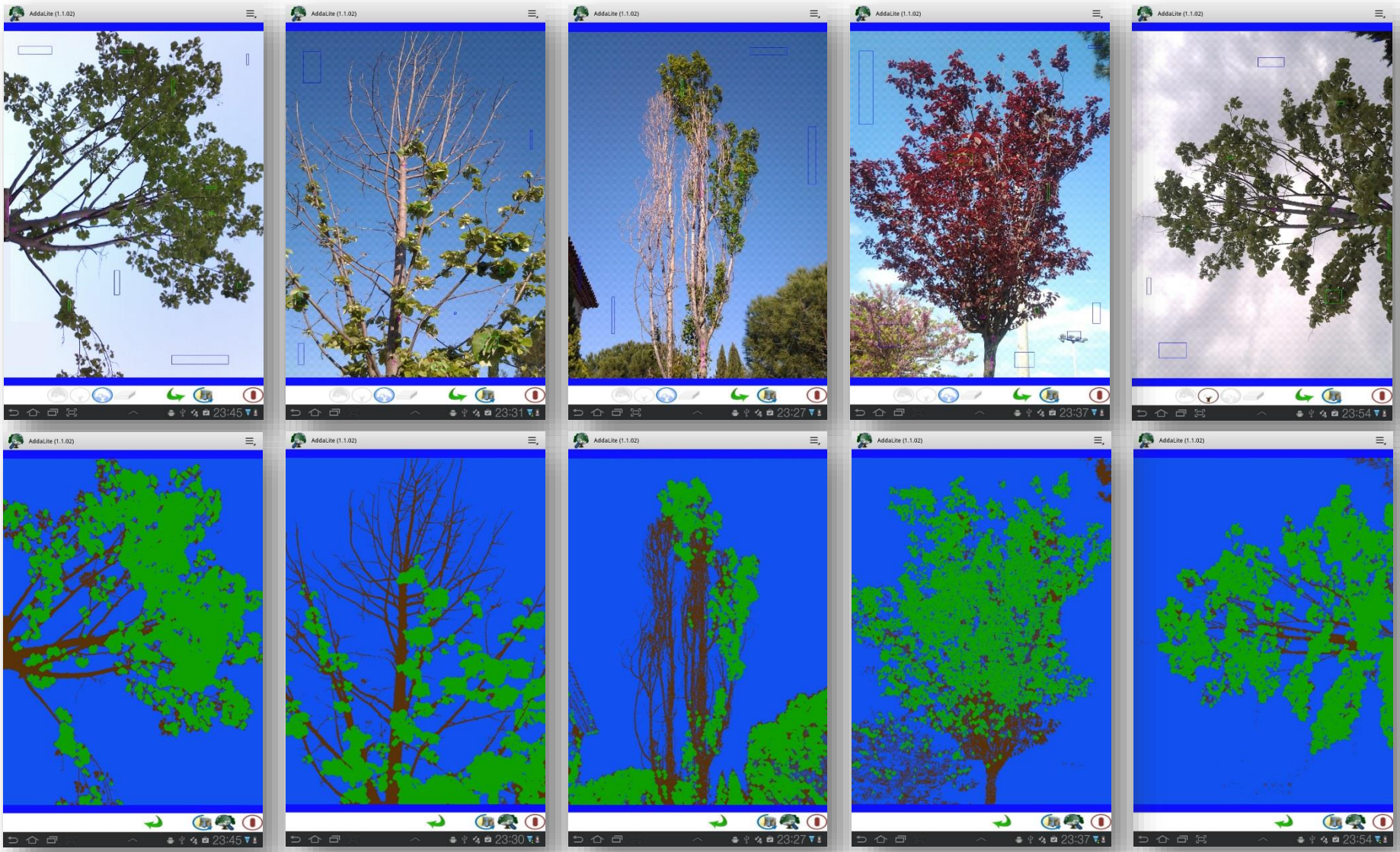
Experimental results



Samsung Galaxy 2 tablet (1 GhZ Nvidia Tegra)

35 s for a 2408 x 1536 pixel image

Experimental results



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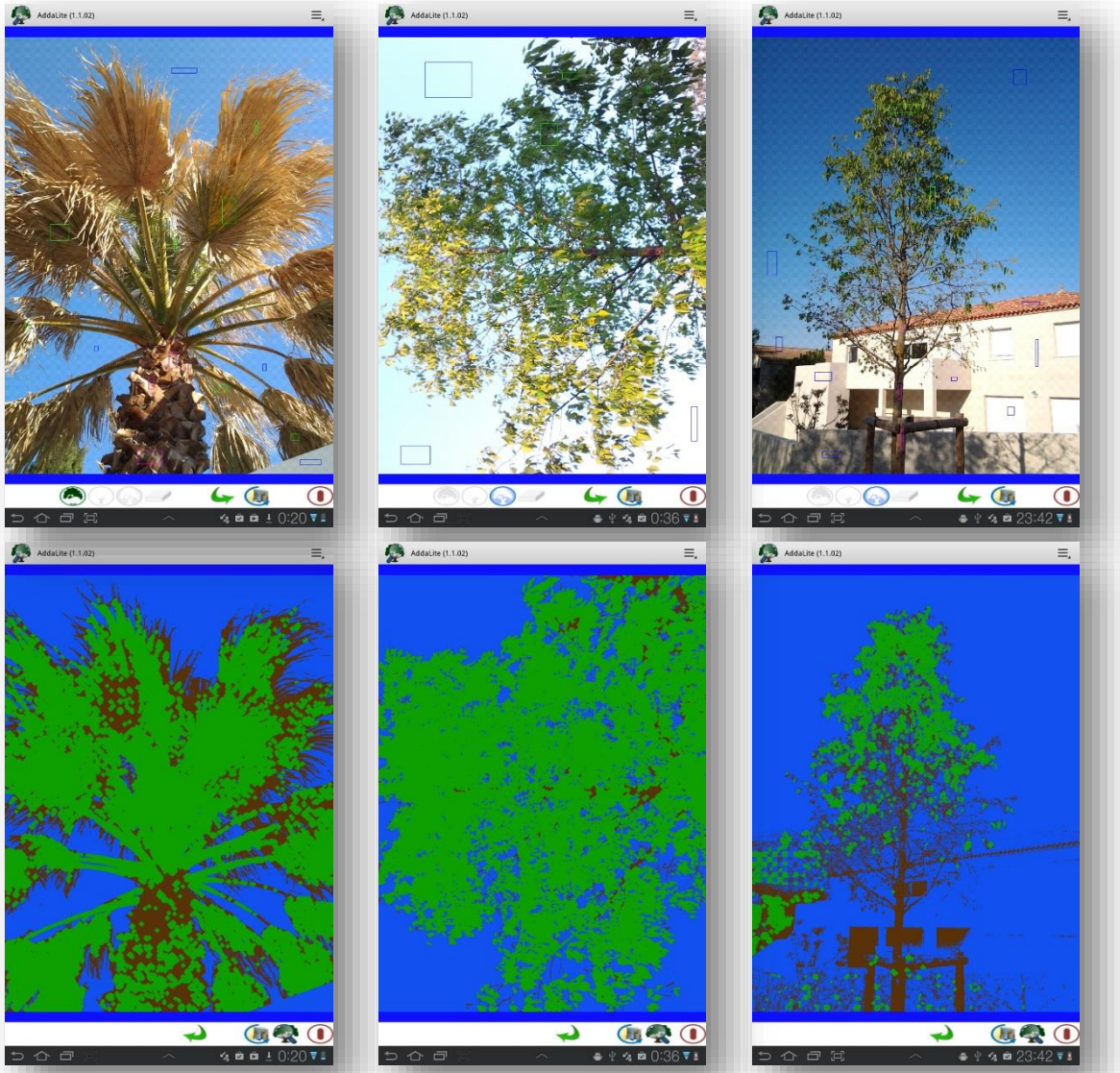
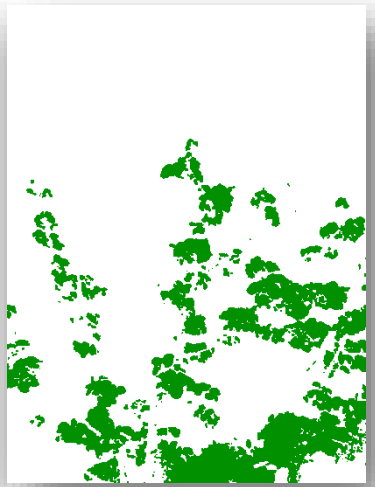


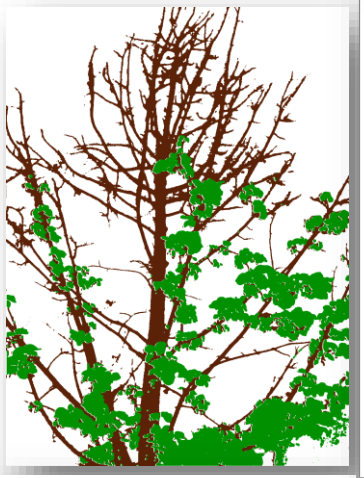
Samsung Galaxy 2 tablet (1 GhZ Nvidia Tegra)

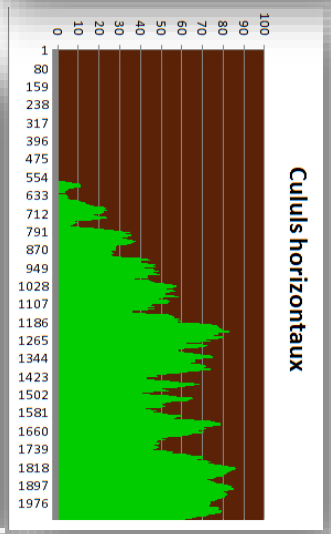
35 s for a 2408 x 1536 pixel image

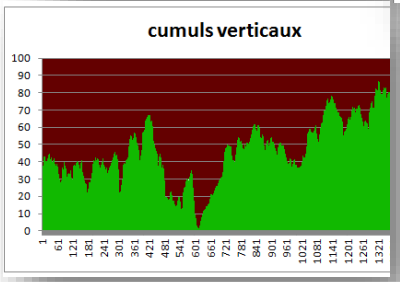
Future work

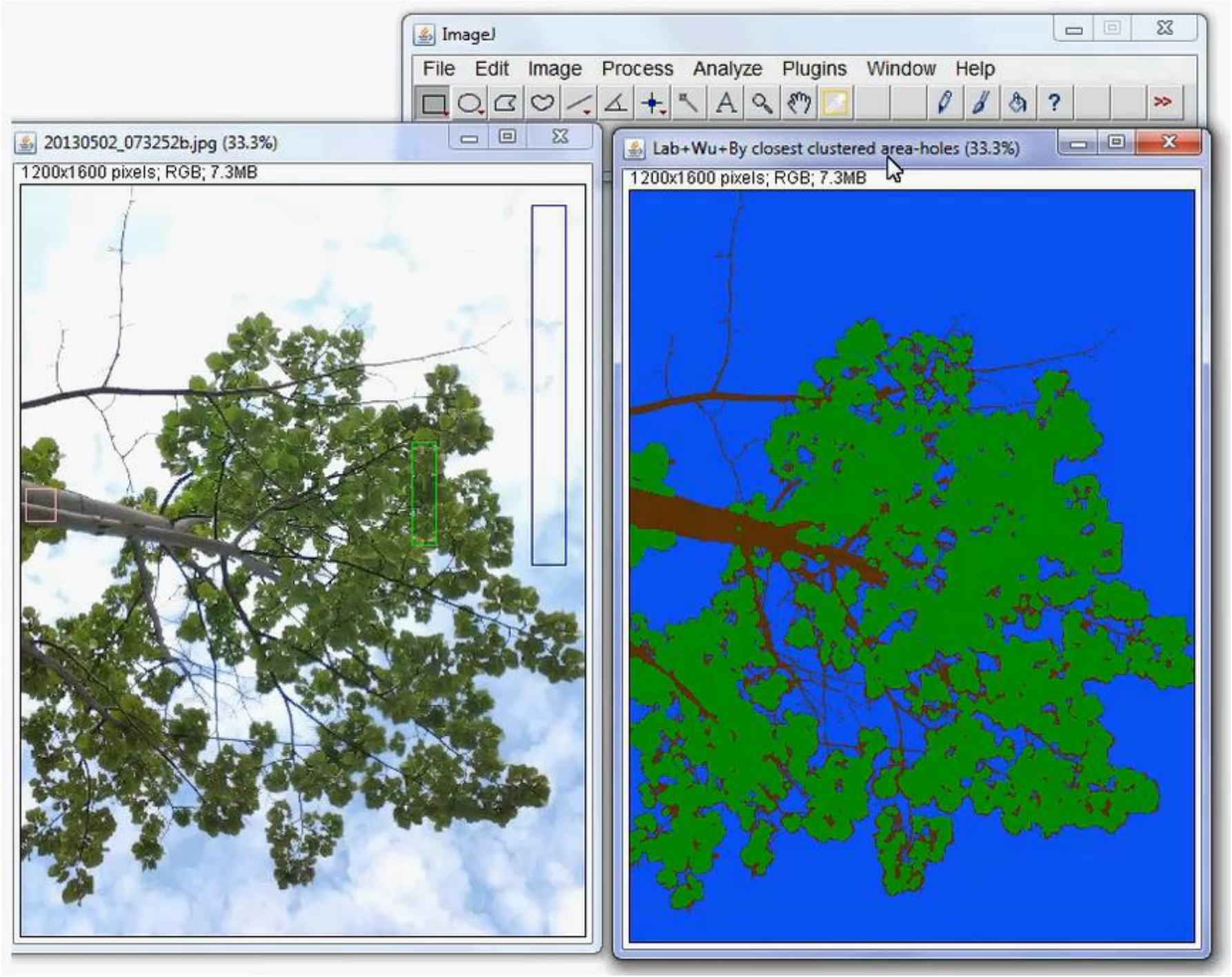
- Computing tree health parameters:
  - ✓ crown transparency
  - ✓ proportion of wood, leaves
  - ✓ regularity of crown shape
- Improve implementation and performance
- Improve ergonomy for a practical application by a non-specialized operator
- Assess the results w.r.t. analyses by experts







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1200x1600 pixels; RGB; 7.3MB
Lab+Wu+By closest clustered area-holes (33.3%)
1200x1600 pixels; RGB; 7.3MB

Thank you for your attention !