Real-Time Quantification of Pollen Tube Dynamics

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Summary

The proposed method is a means of analyzing a sequence of images capturing pollen tube (PT) dynamics. The method takes advantage of the symmetrical nature of the PT in determining PT length and the apical region. Test results show that data extracted via this method is as accurate as manual measurements, while taking about 95% less time. Using this method, images can also be analyzed in real-time which can instruct the data acquisition process.

Challenges

PTs could exhibit turning behavior within the field of view that would make length computations non trivial. The proposed method makes no assumptions concerning growth direction (L-R, bottom-top, etc).

Methodology

To determining the length of the PT, we take advantage of its symmetrical nature and find its line of symmetry (LOS). The LOS is then extended to intersect with the PT apical domain. The length of the resulting line is the PT length.

$$l_{LOS} = \left\{ p=(x,y) \in G : \mathrm{sgn}\left(p_{left}\right) \neq \mathrm{sgn}\left(p_{right}\right) \right\}$$

The apical region is determined by analyzing the turning points in the contour of the PT. The turning points are found by fitting an n-component Gaussian model to the distribution of points along the contour.

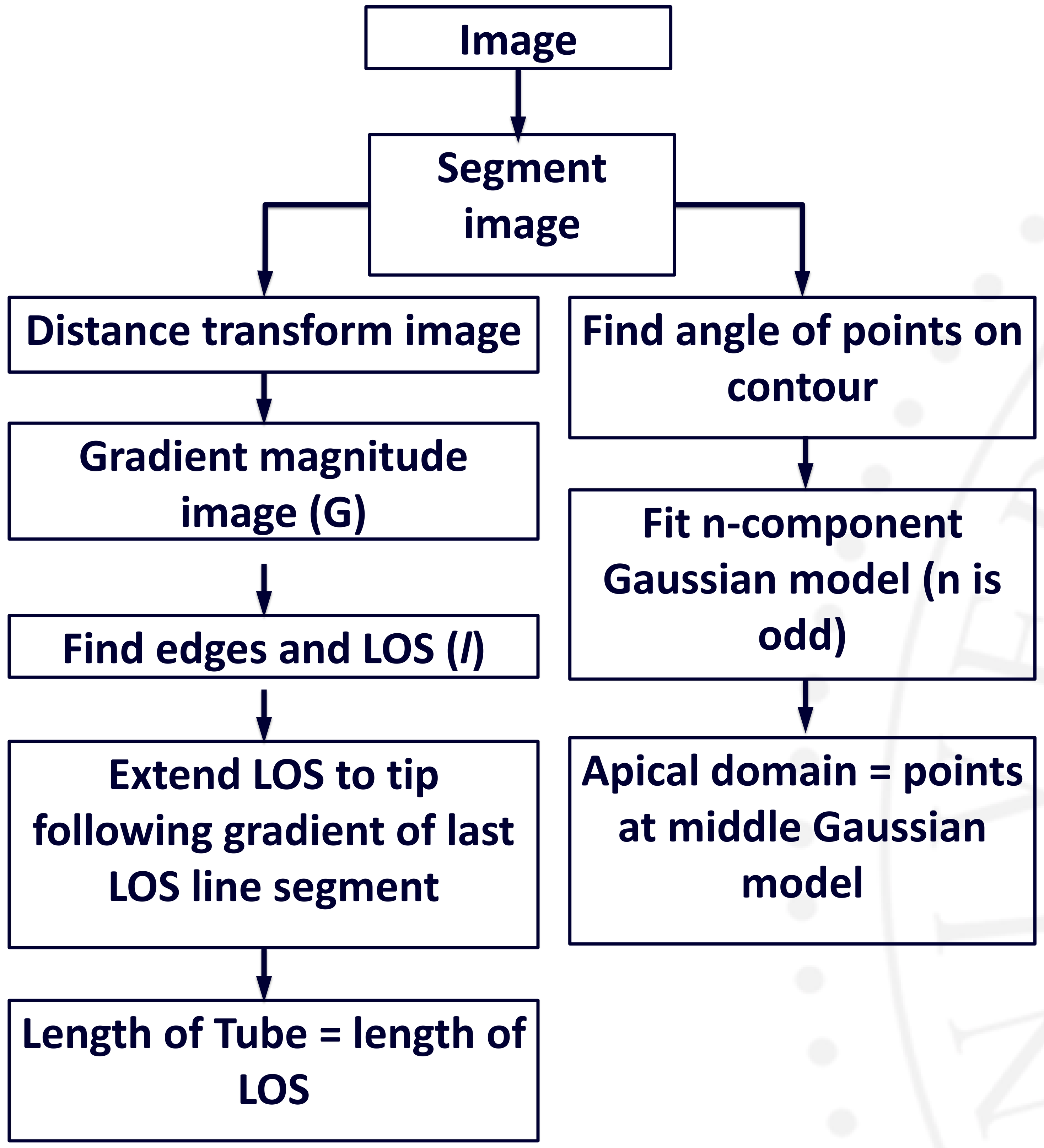
Methodology

There is always an odd number of turning points indicated by local peaks in said distribution. The mean of the central Gaussian component marks the tip of the apical region.

$$l_{AR} = \left\{ p=(x,y) \in C : \mu - \frac{n}{2} \le p \le \mu + \frac{n}{2} \right\}$$

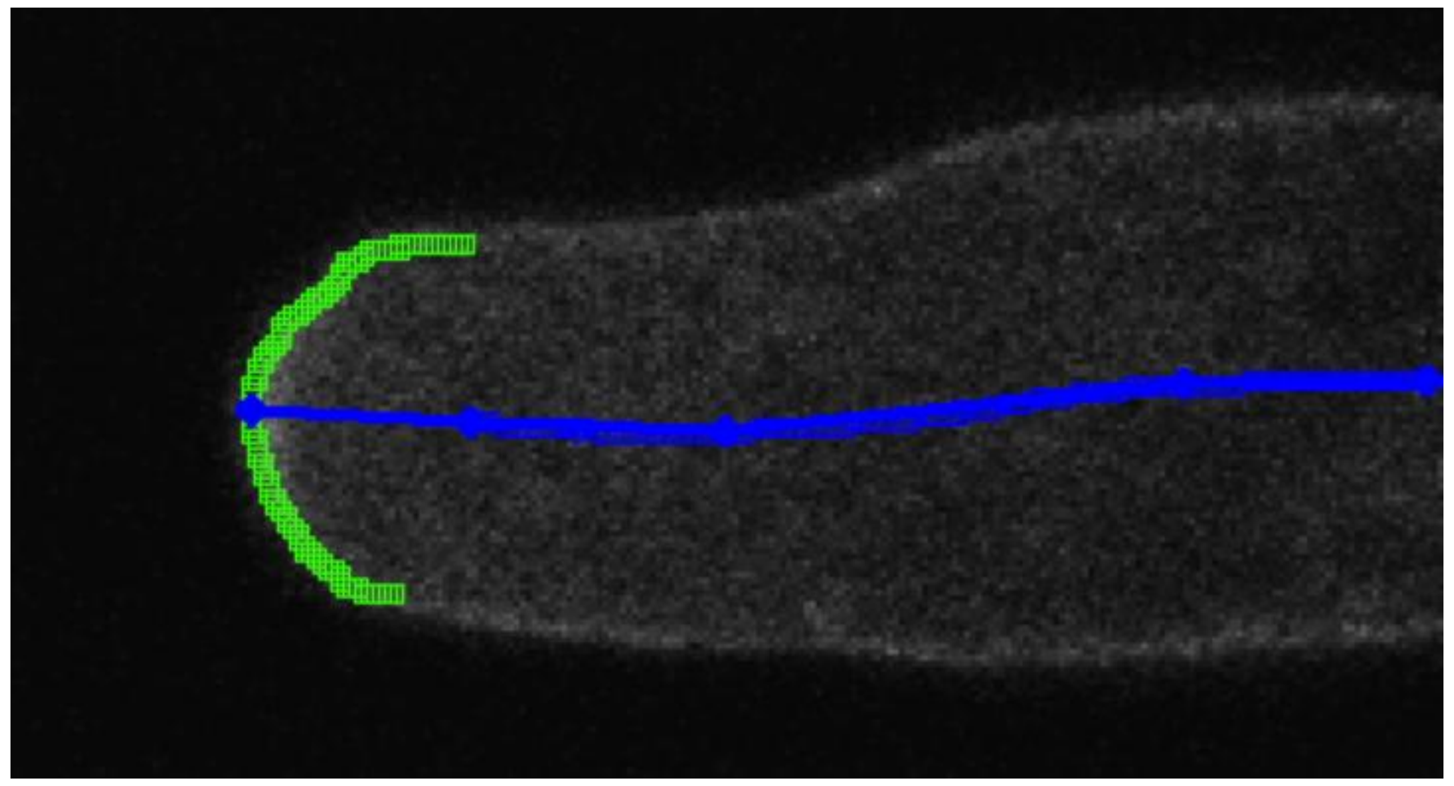
where C is the set of contour points, n is the diameter of the tube, and μ is the mean of the central Gaussian component.

Algorithm Block Diagram

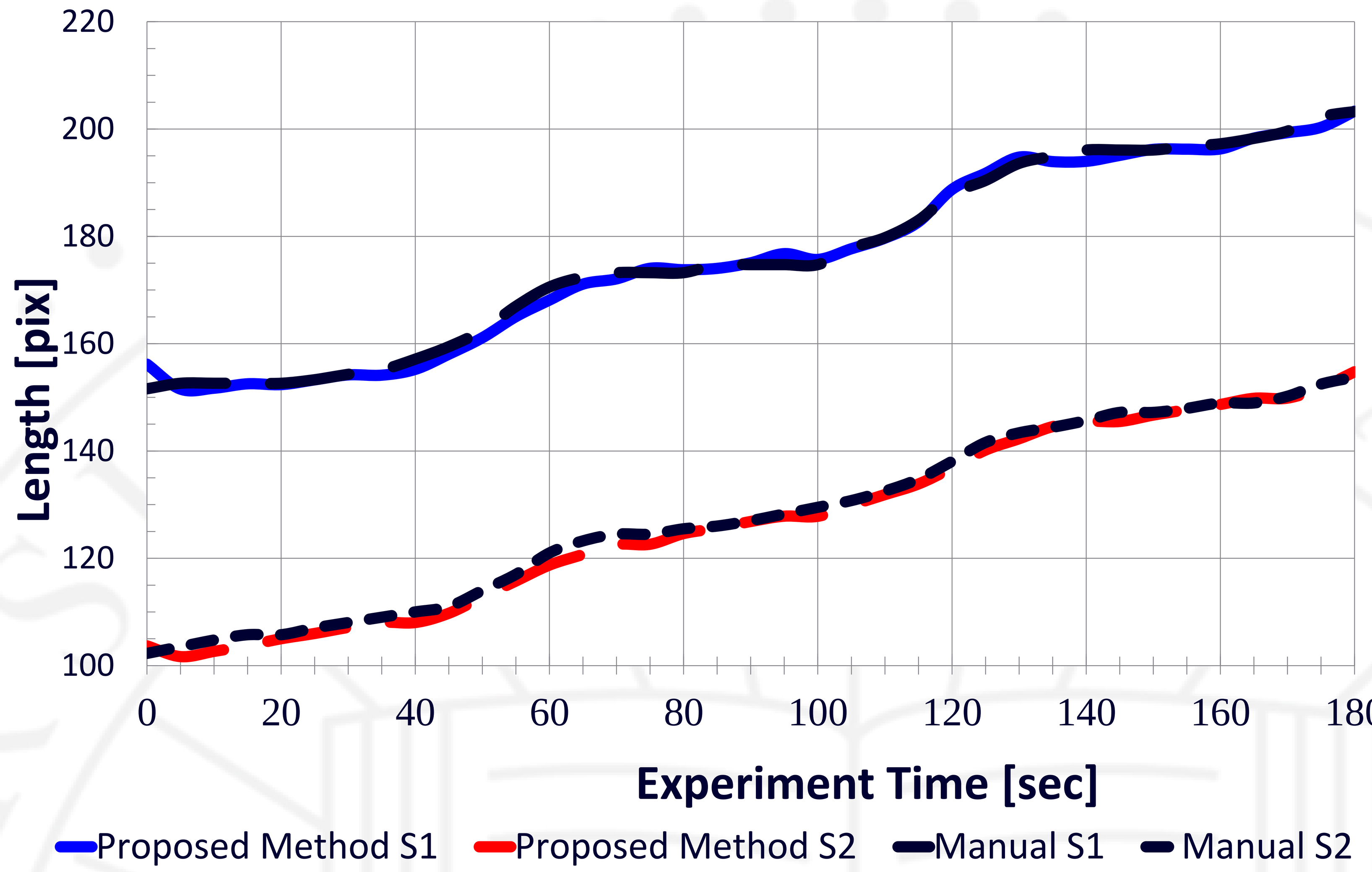


Algorithm for finding tube length and apical region

Results



PT analysis showing LOS (blue) and apical region (green)



Results from the analysis of data sets; 37 images/set. MSE = [1.789 1.650] pixels.

Conclusion

In the future, the segmentation approach will be improved to handle images of most modalities (phase, bright field, etc).

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