Instance Mask Growing on Leaf

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Introduction

Contour-based instance segmentation methods represent masks through a series of points. However, the point number is fixed once the model is trained, which limits the model's flexibility in dealing with various instances. We follow this issue and propose VeinMask to formulate the instance segmentation problem as the simulation of the vein growth process and to predict the major and minor veins in polar coordinates for instance segmenting.

Besides, centroidness is introduced to help suppress low-quality instances. Furthermore, a surroundings cross-correlation sensitive (SCCS) module is designed to enhance the feature expression by utilizing the surroundings of each pixel. Additionally, a Residual IoU (RIoU) loss is formulated to supervise the regression tasks of major and minor veins effectively.

Methods

We construct a single-shot framework based on VeinMask to segment instances precisely through an appropriate number of contour points dynamically. Our method aims to simulate the leaf vein growth process to reconstruct instance masks. It assembles contours by the `root' and `node' classification and `major vein' and `minor vein' regression. VeinMask represents instance masks according to the combinations of `root' and `major vein', and `node' and `minor vein' respectively. In practice, we train our model to fit a polar coordinate with n directions , where each direction will generate a single contour point. For some complex masks, our VeinMask will generate extra points dynamically based on the polar coordinate for refining twisty parts of contours.

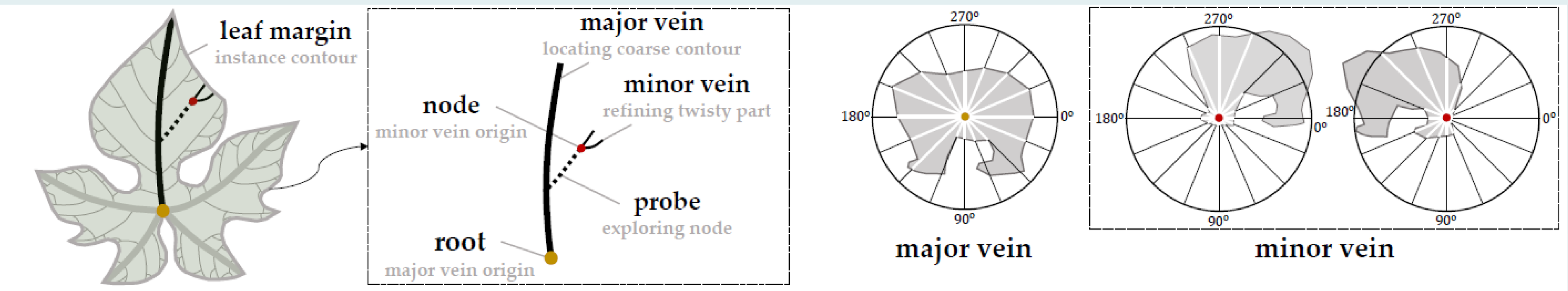
Conclusion

In this work, we design VeinMask to provide a natural and interesting solution for enhancing the flexibility of contour-based methods. Meanwhile, we introduce centroidness and RIoU loss for enhancing the model's ability to segment instances without costs. Importantly, they can be used directly in existing state-of-the-art center classification and offset regression-based architectures. The performance can be effectively enhanced by replacing their centerness and loss function with our centroidness and RIoU loss. Additionally, we construct SCCS to help feature expression of the offset regression. It can be embedded into other architectures and brings performance gains with slight computational costs. We hope the idea that combines leaf vein morphology with instance geometric characteristics will inspire future work, and the proposed centroidness, RIoU loss, and SCCS can become basic components of other approaches.

Contributions

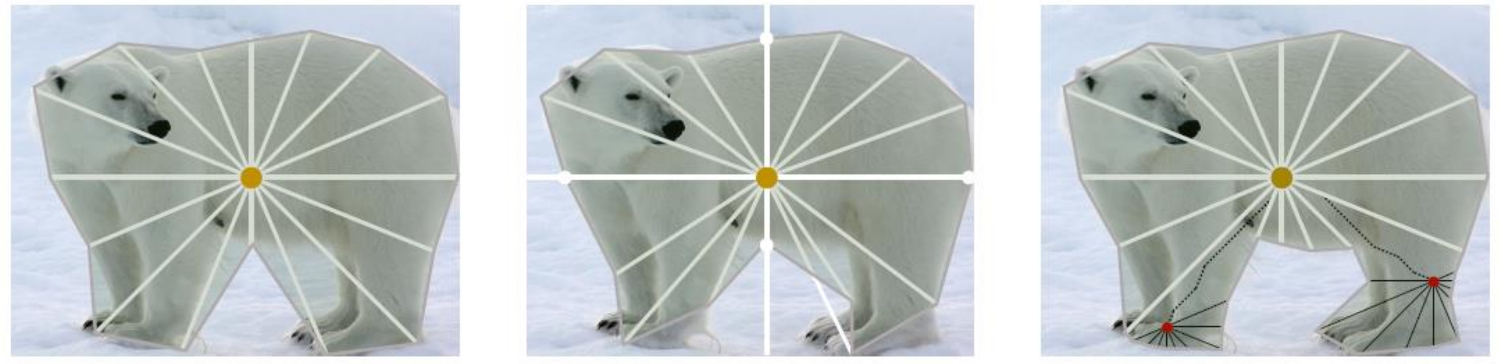
- **We combine morphology with deep learning to design a VeinMask, which simulates the leaf vein growth process to generate an appropriate number of contour points for representing instances. It helps enhance model's ability for dealing with different shape masks flexibly.**
- **A Centroidness is proposed for suppressing low-quality results. It focuses on the instance centroid and spreads around in a Gaussian distribution related to the instance geometries, which can easier bring significant performance gains for instance segmentation tasks compared to the centerness in FCOS and PolarMask.**
- **A surroundings cross-correlation sensitive (SCCS) module is introduced. It helps our model enhance the feature expression by utilizing the surrounding information of each pixel to encourage regression tasks. Importantly, the module ensures the enhanced pixel dominates to surroundings, which can suppress the negative effects brought by surrounding features.**
- **A Residual IoU (RIoU) loss is formulated for supervising the regression of the major and minor veins. Remarkably, it inherits the IoU loss~\cite{yu2016unitbox} advantage and focuses on the residual between the predicted and real values, which is more effective for instance segmentation tasks compared to IoU loss and Polar IoU loss.**

Overall architecture



(a) VeinMask structure (b) Vein in polar coordinate

Figure 1: Visualization of VeinMask. (a) shows the details of VeinMask and (b) illustrates that how those major and minor veins are modeled in the same polar coordinate.



(a) PolarMask [23] (b) E2EC [29] (c) Ours

Figure 2: Visualization of the essential differences between VeinMask and previous works. The '**white lines**' in (a)–(c) are predefined for generating a series of points. The point number is fixed once the model is trained. The '**black lines**' in (c) are generated dynamically in the inference process according to instance geometries.