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토마토 가지 적엽점 검출을 위한 세맨틱 RBG-D 영상 기반 3D 포인트 클라우드 구현

3D Point Cloud Construction Based on Semantic RGB-D Images for Tomato Branch Cut-Off Point Detection

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요 약

Converting RGB-D images to a 3D point cloud and sticking them together is a way to have different viewpoints of an object. Using deep learning to recognize or detect objects in 3D space is not a simple task. This paper proposes a method to build a point cloud based on sematic RGB-D images and detect tomato branch cut-off points in 3D space. These RGB-D images are processed by a semantic segmentation neural network.

Keywords: 3D point cloud, semantic RGB-D images, semantic segmentation neural network, cut-off point

1. Introduction

Branch pruning is an important task in tomato planting in smart farms. There are some pruning methods, such as removing the fourth and the fifth branch below the first flowers or removing branches under a position. Our project aims to develop an automation tomato branch pruning solution. Although there could be many ways on choosing which branch to remove, these branches should be recognized in 3D space with the cut-able point of each branch.

We propose a method using semantic RGB-D images to construct a 3D point cloud instead of using normal RGB-D images. The tomato plant parts and the cut-able points of branches are detected in RGB-D images. This information is used to build a semantic point cloud. This point cloud shows the final coordinates of branch cut-off points.

2. Proposed Cut-off Point Detection

The proposed method consists of 5 steps: take RGB-D images, find the transformation matrix between RGB-D images, detect tomato branches and cut-off points, construct a 3D point cloud, and find 3D cut-off points in 3D space as in Figure 1. In the first step, RGB-D images can be taken by different types of RGB-D cameras. If RGB-D images are from one camera, their position can be calculated by EPnP [1] or UPnP [2] algorithm. If RGB-D images are taken from many cameras, these cameras should be calibrated to find transformed matrixes between them.

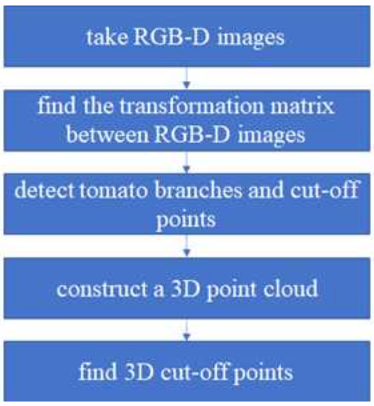

Fig. 1. Flowchart of the proposed method.

.In the next step, a semantic segmentation neural network such as Unet[3], Deeplab V3[4] to detect tomato parts. In this research, we focus on branches and their cut-off points, so we only detect branches, stems, and suckers which are the skeleton of tomato plants as in Figure 2.

감사의 글 : 본 결과물은 농림축산식품부의 재원으로 농림식품기술기획평가원의 스마트팜다부처패키지혁신기술개발사업사업의 지원을 받아 연구되었음(421032-04)

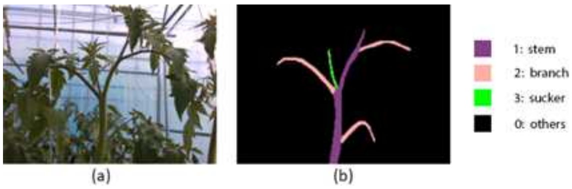

Fig. 2. Semantic image of tomato plant .

Also in this step, we propose a method to find the branch cut-off points in 2D images including 5 steps:(1) extract the branch layer and stem layer; (2) remove noises; (3) separate one branch layer into different single branch layers; (4) enlarge single branch layer and stem layer; (5) find the center point of the intersection region. Results of this step are semantic RGB-D images like Figure 3. (a) and (b) images in Figure 3 show one tomato plant and share the middle plant part. We have to convert the two images to be one object, which presents the plant, by converting them into a 3D point cloud.

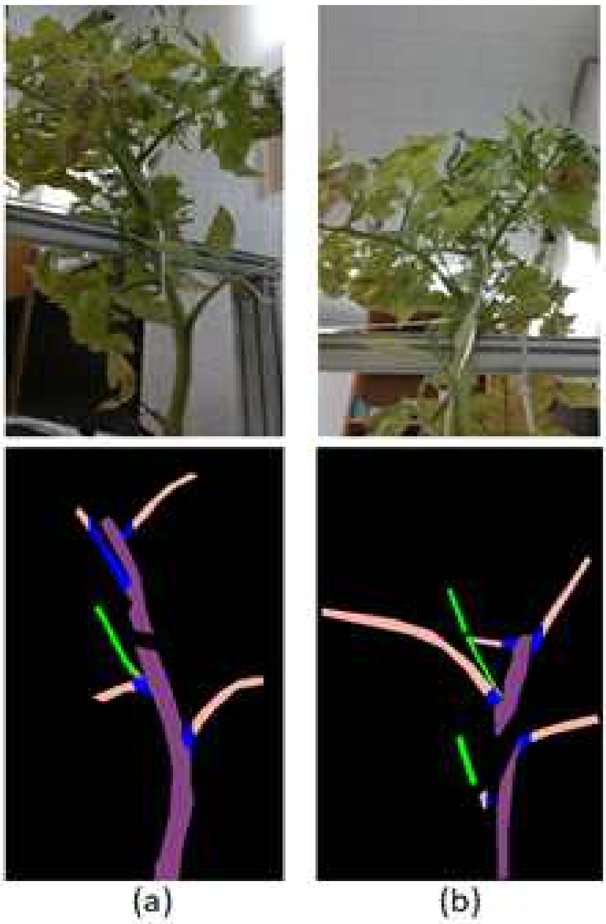

Fig. 3. Cut-off regions of 2 RGB-D images.

In the final step, cut-able regions, which are blue in Figure 3, are combined from different RGB-D images. Now, these regions should be detected again, and find the cut-off points in the center of these regions.

3. . Experiment and Result

In our experiment, we use two Realsense D435 cameras to capture RGB-D images. One camera captures the low part and one camera captures the high part of the tomato plant as in Figure 3. We use Kalibr software to find the transform matrix and use the ICP algorithm to refine the transform. Figure 4 shows the 3D semantic point cloud of the tomato plant. It is easy to find that the normal point cloud (a) is difficult to process to find the cut-off point. The point cloud (b) is the step fourth of the proposed method. The point cloud (c) is cut-able regions. The cut-off points are the center points of these regions. Three of six coordinates of cut-off points of branches, the result of the proposed method is resulted in the experiment.

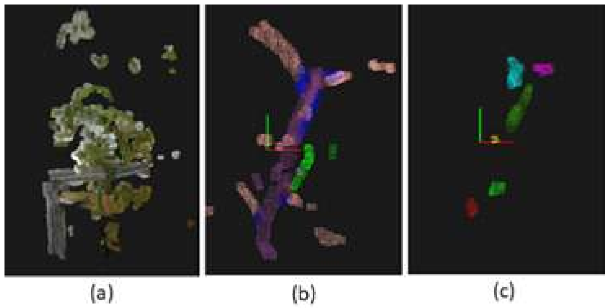

Fig. 4. 3D point cloud images. (a) point cloud of RGB-D images, (b) point cloud of semantic RGB-D images, colored possible cut-off regions.

4. Conclusion

We propose a method that creates a 3D point cloud base on sematic RGB-D images to find tomato branch cut-off points. This method is suitable for complicated pruning processes, in which separate RGB-D images are not capable.

References

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