TREE LEAF IMAGE SEGMENTATION PROGRAM DEVELOPMENT AND ITS APPLICATION ON EVALUATING THE EFFECT OF BREATH PIPES ON CAMPHOR TREE GROWTH

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1. INTRODUCTION

Tree growth monitoring and evaluation in sideroads and parks are important in civil engineering to maintain green environment and ensure safety for transportation and activities in public area. It is important to keep the tree healthy. At the same time, it is necessary to ensure that the tree development will not interfere public space and infrastructure. A breath pipe (BP), a bamboo cylinder filled with soil conditioners and charcoal, is expected to promote the tree growth, and guide root development, thus it may be used to support tree growth in sideroads and parks. This study presents the development autonomous tree leaf segmentation program and its application to evaluate the effect of camphor tree growth under different settings of BPs. The method employed deep convolutional neutral network (CNN) to segment and analyze projected leaf areas of camphor trees. It allows to quickly evaluate and compare the development of trees under different BP settings.

2. EXPERIMENTS AND PROGRAM DEVELOPMENT

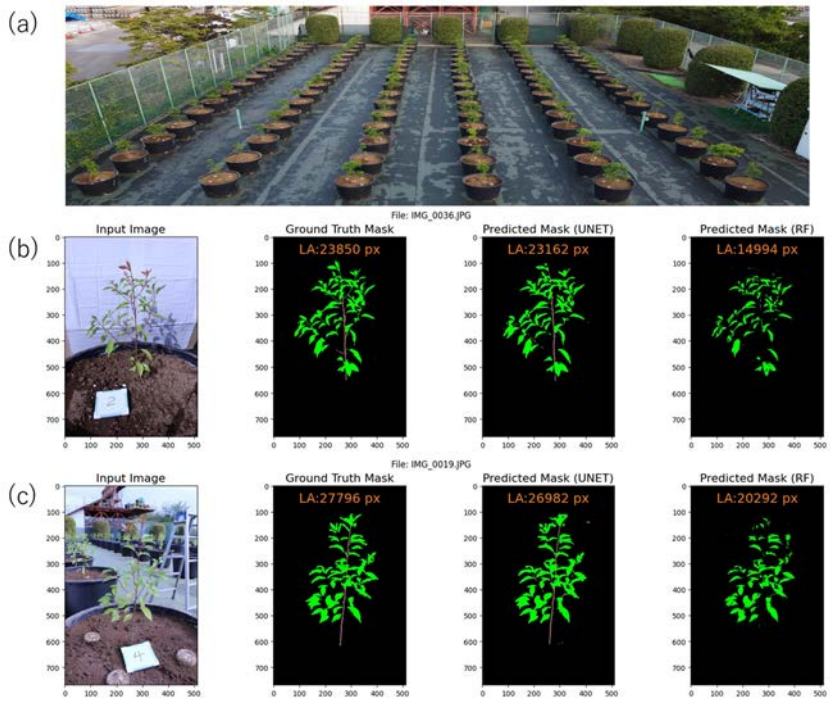

Fig. 2 Leaf image segmentation using YOLOv4 coupled with VGG16-UNET and Random Forest (RF); (a) experimental view; (b) segmentation with background sheet and (c) segmentation without background sheet. LA is leaf area in pixels (px).

2.1 Experimental settings and image capturing conditions

Totally 96 camphor trees were planted individually in each soil pot and have been monitored since April 2020 (Fig. 1a). Zero to three BPs were randomly installed in each pot from the beginning of planting. During monitoring period, only irrigation water was supplied. Tree images were taken one every two months from front, back, left, right direction using Canon kissX5 camera and EF-S 18-55mm f/3.5-5.6 IS II SLR Lens (Canon, Japan) with and without the assist of a background sheet in the back of the tree for preventing any interference of background images.

2.2 Program development

Several methods were applied to segmented leaf images based on RGB image.

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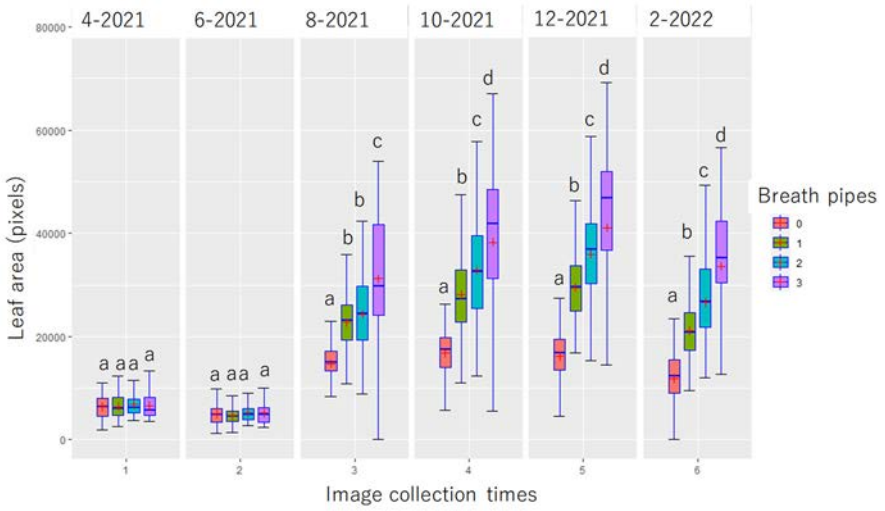

Fig. 2 Changes in leaf area over time under different number of breath pipe treatments. Different letters above the boxplots indicate significant difference of leaf areas at each image collection times (Tukey HSD (Honestly Significant Differences) Test, p = 0.05).

1. Method 1: Traditional method: RGB image was transformed to HSV and LAB, and several image transformations were applied to extract tree leaves.
2. Method 2: RGB, HSV channels and several image features were extracted from images. Random Forest model, a machine learning algorithm, was used to predict tree leaf mask (ground truth) based on the extracted features.
3. Method 3: CNNs: VGG16-UNET, a UNET model with VGG16 backbone model coupled with image augmentation and transfer learning were used to segment leaves.
4. Method 4: CNNs: YOLOv4 was used to detect tree location, the detected tree was then sent to the method 2 and 3 to segment tree leaves.

2.3 Effect of breath pipes camphor tree growth

The program was used to evaluate effect of BP on the growth of camphor tree over time. The statistical tests, ANOVA and post-hoc Tukey HSD (Honestly Significant Differences), were used for the comparisons.

3. RESULTS AND DICUSSIONS

3.1 Program development and performance

Method 1 did not require many teaching data, parameters for method 1 could be obtained with several testing images. The computation was fast. However, it could not be implemented for autonomous analysis because its parameters were sensitive with image capturing condition, some parameter adjustments are required. Method 2-3 required many segmented images for training. Preparation of segmented image was time-consuming especially for a large dataset. In method 3, image augmentation, and transfer learning were very helpful to increase number of images in training dataset and to improve model performance. Although the detection accuracies of method 2 and 3 were high, the models still falsely detected background as leaf section in some cases. The false detection was possibly because of lacking images in training data. Method 4 were improvements of method 2 and 3. With the assistant of tree detection by YOLOv4, the leaf segmentation performance was improved. The model had less effect of background noise in both cases with and without background sheets (Fig. 2b-c). YOLOv4 coupled with VGG16-UNET model gave the best performance with an intersection over union (IOU) score of 84.7 % and a F1-score of 91.1 % (Fig. 2b-c). The work performance may be improved if more training data are provided.

3.2 Effect of breath pipes camphor tree growth

Tree leaves tent to rapidly grow during the summer season and gradually decrease in the winter season (Fig. 2). During the first two months after planting, the differences in leaf areas were insignificant among BP treatments. After four months, the differences were clearly observed. The leaf area increased with the increase in number of BPs (Fig. 2). Similar trends were also observed with tree heights and tree crown spreads. Results indicate BP can enhance the growth of camphor.

4. CONCLUSION

Measuring tree leaf area are importance for tree growth evaluation. There are many methods to segment tree leaves. The combination of object detection YOLOv4 and image segmentation VGG16-UNET gave a stable and great performance. It was less sensitive with tree background image, and image capturing conditions, thus it allowed the analysis and evaluation are fully automated at on-site measurement. The model performance and stability can be improved by improving the quality and diversity of tree images in the training datasets. The analysis indicates that BP significantly promoted the growth of camphor trees in terms of tree sizes and tree leaf area.