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Trees Detection on Google Street View Images Using Deep Learning and City Open Data

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For almost every cities and towns, street trees play an important role in representing seasonal change of the street view. Nowadays, lots of countries start promoting open data. Among these data, very useful information related to street trees are well documented with free access by many city governments. At the same time, Google Street View provides the view of a certain surrounding by composing stitched images which are shot by specialized vehicles moving along streets and alleys. However, few research reports have been published on utilizing city open data for trees detection on Google Street View. Therefore, in this study, we aim to perform trees detection on Google Street View Images by utilizing Deep Learning technologies and city open data.

1. Motivation and Research Background

Street Trees are an indispensable component of great neighborhoods. Street trees play an important role for:

1. representing the style of a city, trees provide beauty and aesthetic appeal for the urban landscape.
2. improving environmental quality, especially for reducing air pollution.
3. strengthening urban amenity because trees provide spaces for rest and relaxation.

Therefore, street trees management is always an important issue for city and county governments. It is especially true for cities such as Tokyo and Washington DC where have beautiful cherry blossom seasons.

Nowadays, many countries start promoting open data. The concept of open data is that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control. Among the open data provided by some city governments, very useful information related to street trees are well documented with free access. For example, many well documented information of street trees can be accessed form the open database of Taipei and New York city, as shown in figure 1 and figure 2. These useful information includes: tree species, tree height, diameter at breast height, growth status, and position.

Figure 1. Tree's data in Taipei

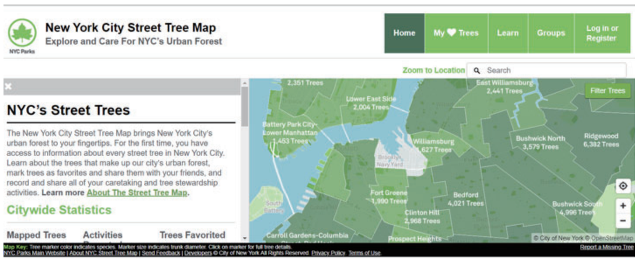

Figure 2. Tree's data in New York

At the same time, Google Map has become the most common tool used for exploring street maps. There are many services available on Google Map. And Google Street View is one of the feature derived from Google Map for improving users' perception of real world. It shows the view of a certain surrounding composed by stitched photographs shot by specialized vehicles moving along streets and alleys. However, these street images are static, no matter which season is now. Moreover, as shown in figure 3, it is still difficult to accurately locate trees on street images by using Google API because of the

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GPS position bias of moving vehicles and the image stitching algorithm.

Figure 3. The shifting problem of tree positions on street picture due to GPS errors

Therefore, in this study, we aim to develop a new approach which detects trees position on Google Street View Images by utilizing Deep Learning technologies and city open data. The remainder of this paper is organized as follows: in section 2, the related works are introduced; in section 3, our prototype system are explained; in section 4, the current experiment results are shown; and finally in section 5, the conclusion are discussed.

2. Related Works

2.1 Trees Detection

In comparison with the number of research works developed for detecting car and people, there are fewer papers published on solving street trees detection problem. In 2006, Wajid Ali proposed a tree detecting method by using the color and texture of trees as the basis for detection in a forest environment [1]. Later, Y. Lu and C. Rasmussen proposed a tree trunk detection algorithm by using contrast templates in 2011 [2]. These studies have good results with limitations of vertical trees on grass fields. In addition, Harri Karrtinen et al. evaluated the quality, accuracy, and feasibility of automatic tree extraction methods, mainly based on laser scanner, which requires high precision and expensive instruments to collect and detect data from trees [3]. It is still very difficult to detect trees images because trees have very complex and various textures and shapes.

2.2 Machine Learning Technologies

Machine learning technologies have been widely applied in solving many problems such as object recognition and route planning, and have achieved many good results in recent years [4]. For example, in1995, C. Cortes and V. Vapnik proposed the Support Vector Machine algorithm which separates the attribute space with a hyperplane to maximize the margin between different classes [5]. Later, in 1997, M. Dorigo, L. Gambardella used the Ant Colony Optimization approach to solve the Traveling Salesman Problem successfully [6].

3. System Implementation

Our system can be divided into the following three stages:

3.1 Adopting Deep Learning approaches for trees image segmentation.

In our prototype system, we trained U-Net and Seg-Net for Deep Learning as shown in figure x. Both U-Net and SegNet are kinds of Convolution Neural Networks. The U-Net was developed for biomedical image segmentation in 2015 [7]. SegNet was developed for autonomous driving applications to enable vehicles understand road scenes in 2016 [8]. For the research convenience, we try to reduce the network size and complexity by pre-categorizing trees images into several groups based on the tree species and seasons. Then each CNN is trained separately for different groups.

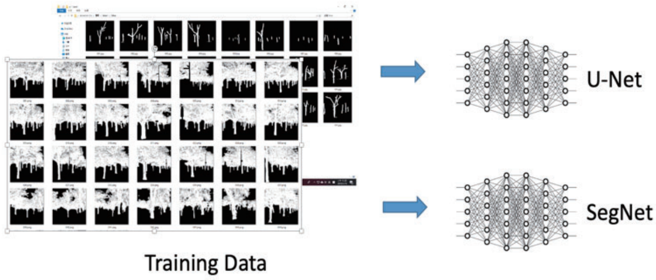

Figure 4. System Flow 1

3.2 Selecting appropriate Deep Learning models for tree segmentation.

By cross referencing the city open data, and the location/compass/time information of Google Street View images, appropriate Deep Learning models are then used for image segmentation of tress. For example, as shown in figure y, our system first determines that there should be a tree contained in the image, according to its GPS and compass information. Then we select the U-Net and Seg-Net which are trained by using deciduous trees images in Spring for image segmentation.

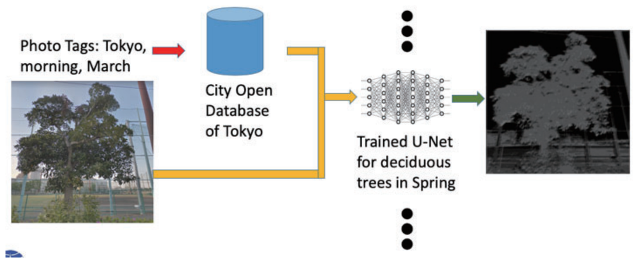

Figure 5. System Flow 2

3.3 With the segmentation results as the guidance, adopting conventional image processing approaches to detect and extract useful information of trees on street pictures.

Currently, we adopted the flood fill algorithm with the segmentation results as the guidance for edge extraction. One of the results is shown in figure 6.

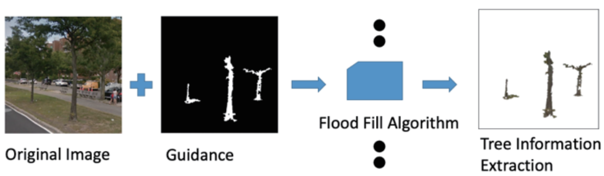

Figure 6. System Flow 3

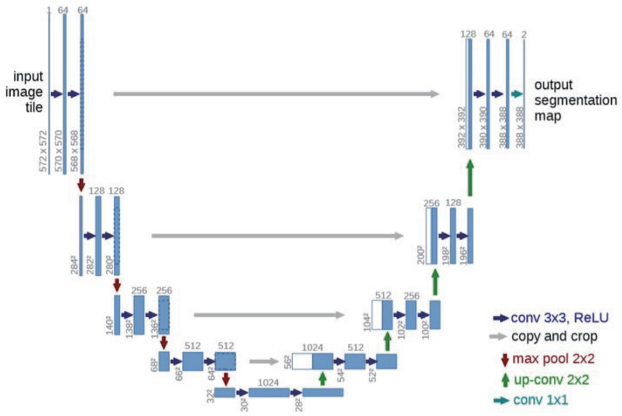

Figure 7. U-Net

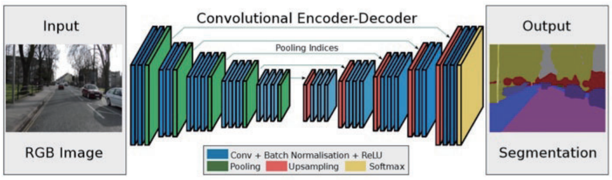

Figure 8. Seg-Net

4. Current Experiment Results

Up to now, we use 100 street view pictures for experiment, Only 40 labeled positive training data are used currently, 30 pictures for testing data, And 30 pictures for negative training data are not adopted yet.

Figure 9. Street Picture in Puli

Figure 10. Segmentation Result use Seg-Net

Figure 10 illustrates an image segmentation result of Seg-Net for a Google Street View picture of Puli, Taiwan in figure 9. The blue regions are for sky, red regions for buildings, white regions for cars, black regions for road, and green regions for plants which are our target for further processing.

Figure 11 is another example of the original street images. And figure 12 illustrates it segmentation results of U-Net trained by deciduous trees images in summer respectively.

Figure 11. A street image which contains multiple trees.

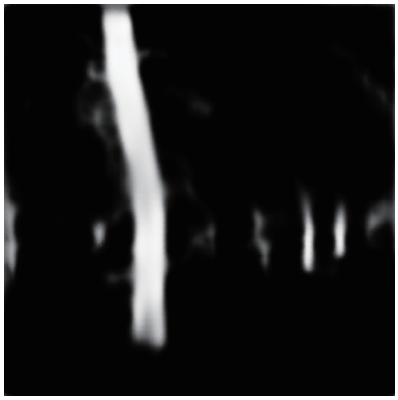

Figure 12. Segmentation Result using U-Net which is trained by trees images in summer.

5. Conclusion

In this research, by utilizing Deep Learning technologies and city open data, we developed a street trees detection method. And we are currently collecting and labeling more images of the 10 most common street trees in 4 seasons for training the Deep Learning models and fine tuning them. There are many parts remained at the conceptual-level, especially at the stage 3, in our prototype system. In addition, more research efforts are required for extracting and separating the shapes of overlapping tree crowns. However, the experiment result still shows that our system has the potentials to:

1. Provide an effective approach for automatically monitoring and managing street trees in smart cities.
2. Severe as a useful tool for users to explore and share the great values of trees in cities and towns.

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