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Assess the Distribution of Informal Green Space Using Google Street View in Ichikawa City, Japan

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Abstract: The green space provides many benefits for social, environment and ecological for urban life. There is the need to develop a proper plan to ensure the well-being of residents by use other space as supplemental for urban green space (UGS). Informal green space (IGS) was long use as a solution for shortage of UGS and being used widely in recently years. However, it hardly analyzes and manages IGS efficient by traditional survey method because of its characteristics. Google street view (GSV) is a geospatial platform provided free large ground-based database 3600 photographs along streets that available on web interface. It is high possibility to use GSV in assess the distribution of IGS for managing and planning urban greenery and master plan. Ichikawa city, Chiba, Japan covers 57.45 km^2 while provides about 7.28m^2 green space area per capita, far from meet the requirement 10m^2. By choosing this city, the field survey result of previous research could be used to compare to evaluate the accuracy of the remote sensing method. GSV images are downloaded by Street View Download 360 from the network of interval point along the road to detect IGS. After considering the time to acquire GSV and other factors, the 78 meters distance is chosen. The DeepLab V3+ is employed as a semantic segmentation tool and be trained to classify and labeled objects in pictures then separate IGS to surround environment. The map of IGS distribution will be produced from the output data of DeepLab V3+ by using ArcGIS. The final map will be compared with the data of IGS distribution that were recorded in the research of northern part of Ichikawa in 2020 to evaluate the efficiency of this method.

Keywords: Informal Green Space, Urban Green Space, Google Street View, Ichikawa City, Chiba

1. Introduction

The important of green space was mentioned in much research by providing huge social, environmental and ecological benefits for citizens, especially in dense city [1, 2]. Some significant benefits like mitigation of the urban heat island [4-6], reduce stormwater and the chance of urban flooding [5, 6] and benefit of human health in both physical and mental [2, 3]. According to United Nations projection, the proportion of world's population living in city is increasing day by day and this number will reach 68% by 2050 [7]. However, citizens living in this dense environment have limited chance to contact with nature factors while have been suffered from air and sound pollution [8]. Local government, to ensure the well-being of residents, will eventually have proper plan to develop enough urban green space (UGS) as a social service. But due to financial limitation, support for other social projects and huge impact of pandemic recently, many UGS projects are postponed or fail since its facilities and vegetations need regularly maintain [9]. And most of shrink cities in Japan provided low amount of green space per capita by comparison to the standard (10m^2 per person in major cities) [10]. In addition, the existence of greenery view usually increases people's esthetic rating of streetscapes, which would further increase resident's recreation and social cohesion in neighborhoods [11]. That lead to question how we can use other spaces to be supplemental for UGS. Cities of European and American countries had been using vacant land, one type of informal green space (IGS), participating to meet resident's need [12-15] and proved that IGS offered benefits associated with green infrastructure and could alleviate maintenance cost. Nevertheless, although this approach has been introduced to Japan since the 1990s, local government still lack attention to explore this direction and focused on the formal and generally acknowledged UGS such as urban park, forest and cemeteries...

In recent years, the records show a strong demand of citizens for recreational urban agriculture and there are a lot of research on the possibility of this direction around the world [16-18]. While in Japan, some cities such as Yokohama, Osaka have started retrofitting urban parks with area for growing vegetables, but they are still a few rare cases. The research conducted by Rupprecht show positive results in the management of IGS with resident's participation in four representative shrinking cities in Japan and it can improve urban landscape aesthetic with limited management by volunteer while be evaluated considerably higher by residents [19]. Minseo Kim, in research about people's perception and distribution of UGS and IGS of Ichikawa city [20, 21], also pointed out the high potential of IGS as a supplement for UGS and its role in relieving the spatial and financial burden of governments. Moreover, the limitations of IGS are the smaller size than large-scale urban parks, and the continuity of space, therefore it is necessary to combine the GIS analysis to deepen the understanding of IGS distribution.

Given the widespread use of GSV, it is high possibility to use GSV in assess the distribution of IGS for managing and planning urban greenery and master plan. For recently years, IGS has started to get the attention from researchers and scholars but there are still some limitations in research. One of mutual limitations is the impediment to field surveys due to the large area and expensive cost. The purpose of this study is developing a method using GSV to assess the distribution of IGS in Ichikawa City, Japan. In this study, robust virtual surveys of IGS will be conducted.

Ichikawa city (Chiba Prefecture, Japan) is chosen as study site since there are two previous research about IGS proceeded here [20, 21], put a theoretical base for this research to deepen understanding about IGS situation. This city area covers 57.45 km^2 with population about 485,852 (data recorded 2020) while provides nearly 7 km^2 green facilities, which includes 3.45 km^2 urban parks, 2.27 km^2 public green open space and 1.21 km^2 private facility green spaces. Therefore, the green space area per capita is only 7.28m^2 and is far from meet the requirement of Urban Park Act of Japan, which minimum 10m^2 urban park per capita.

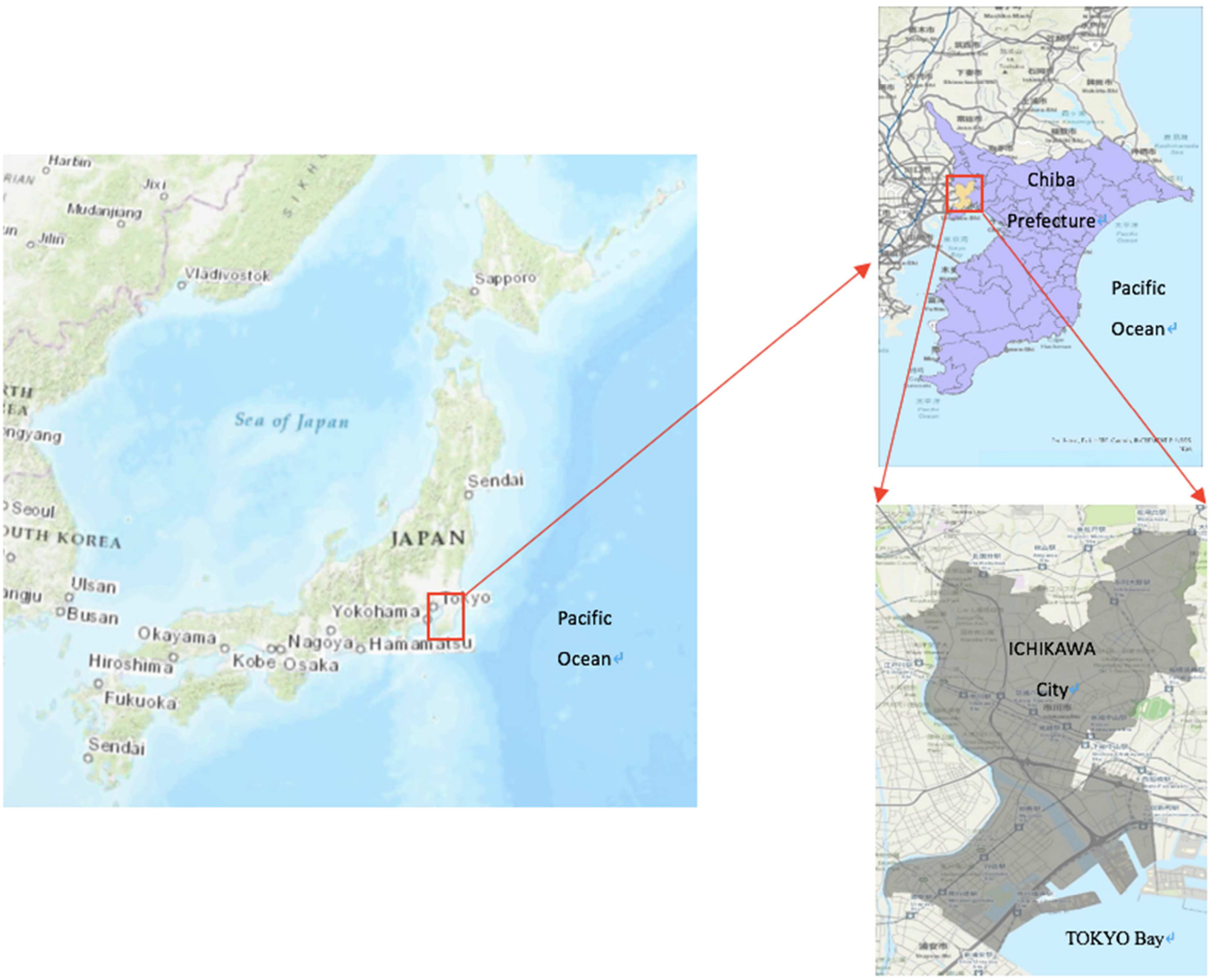

Figure 1. Location of Ichikawa City in Japan.

2. Method

2.1. Google Street View Panorama Collection

GSV images were acquired by Street View Download 360 to detect IGS in Ichikawa city. The distance between each interval points specific in each research project and depend on the size of study site, the popular distance can be seen in previous research such as 20m [30], 50m [31, 32] and 100m [33, 34]. After considering the time require to obtain GSV and the software ability, the size of study area and the efficacy of previous research, the interval of 78 meters was chosen in this study. The networks of 78m interval point along the road is created and images can be download from these points.

2.2. Semantic Segmentation

Semantic segmentation is an advanced method of classifying image into several components, e.g., building, trees, sky, by pixel and can help intelligent systems understand natural scenes. The DeepLabV3+ was employed to classify and detect green area in GSV images. This network was introduced in 2018 with ability to control the resolution of the output feature map through void convolution to realize the balance between accuracy and running time [35]. The software will be trained to recognize and label IGS in panorama picture through the set of sample pictures data.

2.3. Data Analysis

The output data will be imported into ArcGIS to create distribution map of IGS. The final map will be compared with the data of IGS' distribution that were recorded in IGS research of Northern part of Ichikawa in 2020 to evaluate the efficiency of this method.

3. Result and Discussion

The IGS distribution data were obtained from a survey about typology and perception of IGS in 2020. In that research, a grid net with 500x500m was set up with $50m^2$ sample site in each intersection along the north of Ichikawa city. There are 120 sites in total and were visited to get data about land use, form and vegetation. By choosing this city, the field survey result data could be used to compare with the result of this research and evaluate the accuracy of the remote sensing method.

The IGS in Ichikawa city was categorized into nine types: street verges, gaps, vacant lots, railroad verges, water verges, overgrown structure, brownfields, unimproved land, parking lot verges [19-21] (Figure 2). The first 7 types of IGS in Ichikawa similar with types in 4 other shrinking cities in Japan also many other places around the world.

Figure 2. *IGS in GSV aspect: a) street verges; b) gaps; c) vacant lots; d) railroad verges; e) water verges; f) overgrown structure; g) brown fields; h) packing lots verges; i) unimproved land.*

Traditionally, survey about green infrastructure widely used remotely sensed imageries to map and quantify the amount of green space in cities because of many advantages such as largely covered area, synoptic view and repeatability. This matter was discussed in previous research [22-24]. However, the high-resolution satellite images are expensive and hard to access for non-professional users (Figure 3).

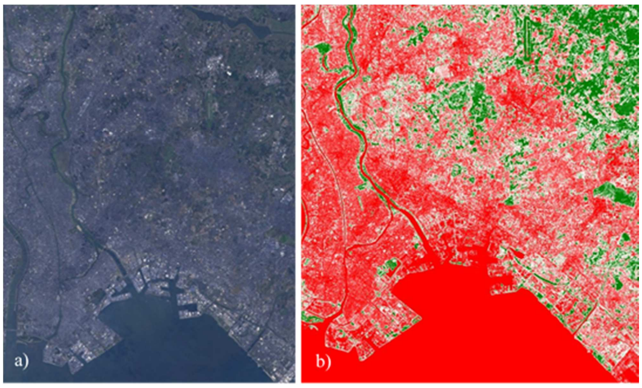

Figure 3. *Green infrastructure survey done by traditional satellite remote sensing with a) surface image from LANDSAT-8 2020 and b) NDVI image for vegetation detect.*

Additionally, it is hard to apply remote sensing using airborne or satellite to survey about IGS since hardly to separate and detect IGS due to its small size (Figure 4).

Figure 4. *Most of IGS is too small to be recognize through top – down view of Google Earth.*

Moreover, the different between the profile view of on the ground view and overhead view from remotely sensed imageries is aerial images cannot fully reflect a pedestrian's perspective (Figure 5).

There is research mentioned about this issue in the past [25, 26]. Street level images, especially Google Street View (GSV) images, have similar view angle with pedestrians so it provides human-centric like method to map the spatial distribution of IGS and have been used in several similar research for characterize greenery in urban streetscapes by quantifying green pixels in images [25, 27] or study the distribution of a forest pest by identifying the pest's distinctive nests [28]. In addition, most of remote sensing remain largely inaccessible to non-experts including most urban forest managers and planners and high-quality remote sensing products are generally expensive. That can be obstructed municipal forest managers to plan and use IGS to retrofit UGS.

Figure 5. *IGS in the image download from Google Street View.*

On contrary, GSV is a geospatial platform that provides ground-based panoramic photographs captured along streets, available both online and through Google Earth with simple interface that can be used by anybody with little effort (Figure 6). This result is responded to previous research confirmed GSV's ability to generated result as same as field survey by a single person while reduce cost and safety risks [29].

Figure 6. *The IGS in street view photo (a) can be seen easily but not be detected in aerial image (b).*

Given the widespread use of GSV, it is high possibility to use GSV in assess the distribution of IGS for managing and planning urban greenery and master plan. For recently years, IGS has started to get the attention from researchers and scholars but there are still some limitations in research. One of mutual limitations is the impediment to field surveys due to the large area and expensive cost. The result of this study is to map the spatial distribution of IGS and assess the possibility to access IGS without money for transportation or extended physical effort, so it can benefit specific population groups such as older adults, children or adolescents. This study also proposes the framework method for similar research in future to assess green space in dense urban.

The following process is conducted to archive the final result (Figure 7). First step is using Street View Download 360 to obtain multiple panoramic images. The images outside research area will be removed later. Next, DeepLab V3+ will be used as semantic segmentation tool to labeled objects in photos to detect IGS automatically (step 2). The software is trained by using training model dataset which contain cityscape images similar to IGS. By using this software, the public green space and IGS can be treated with the same criteria in all photos therefore it will be easily estimating the accuracy of this method. Output data from DeepLab V3+ will be import into ArcGIS (step 3) for create a distribution map (step 4). In final step, the distribution map will be compared with the distribution map of IGS of northern part of Ichikawa city which was discuss in the research about typology and distribution of IGS in 2020 to evaluate the accuracy (step 5).

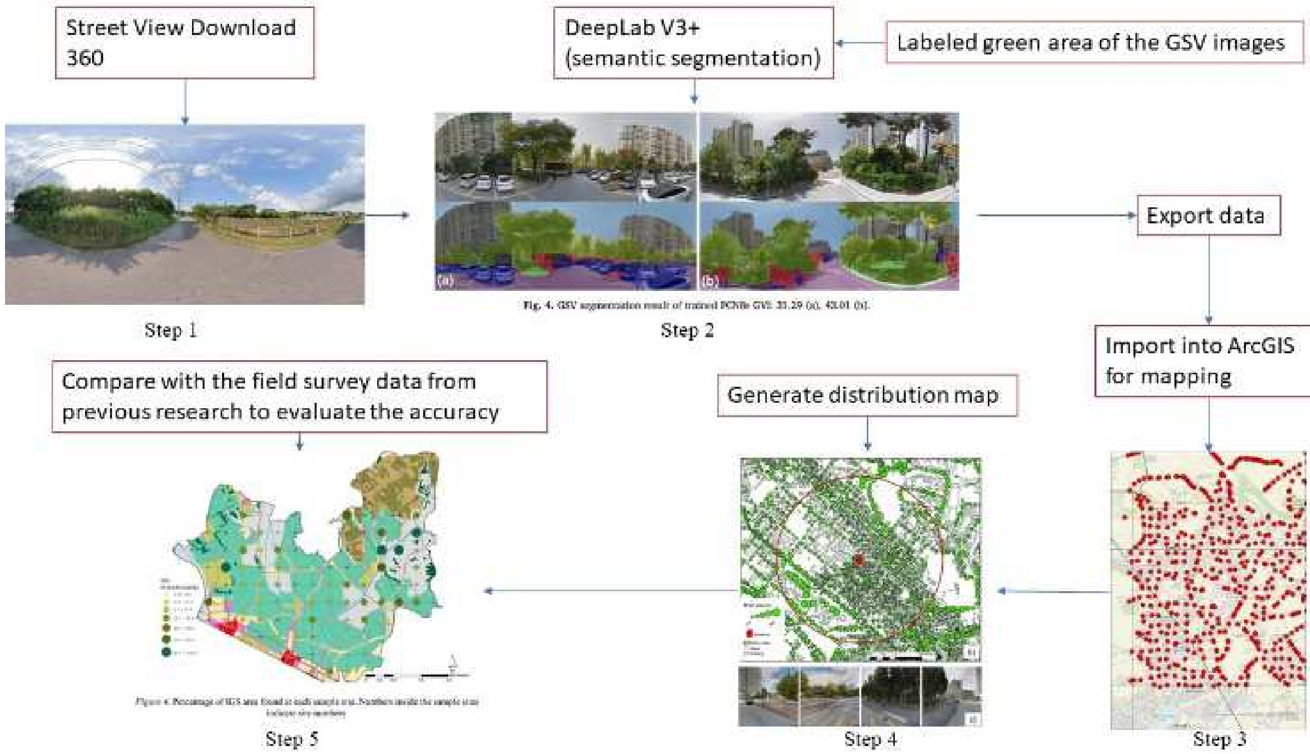

Figure 7. *The process of assessing the distribution of IGS in Ichikawa city using Google Street View and deep learning.*

4. Conclusion

The result of this study is to map the spatial distribution of IGS and assess the possibility to access IGS. First step is using Street View Download 360 to obtain multiple panoramic images. The images outside research area will be removed later. Next, DeepLab V3+ will be used as semantic segmentation tool to labeled objects in photos to detect IGS automatically (step 2). The software is trained by using training model dataset which contain cityscape images similar to IGS. This method has generated the result that match with the field survey of previous research while it takes less effort and can be done automatically in any country. Applying this method can be reduce much human risk and cost than traditional field survey method. However, there are many issues in develop accuracy deep learning system and the distortion of sphere photos downloaded from Google Street View so it need to have more research about this matter in the future.

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