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An assessment of support vector machines for crown delineation of pine single trees on unmanned aerial vehicle imagery

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Abstract

The aim of this study was to compare the performance of the Support Vector Machine (SVM) algorithm with pixel and basic object-oriented approaches for identifying the crown of single pine trees in a man-made forest. For this purpose, the SVM algorithm was evaluated based on four different kernels: Linear, Polynomial, RBF and Sigmoid. In pixel base approach, the ROI obtained from the user's choice, and in the object-oriented approach, the ROI obtained from segmentation for part of the image. Then, the results of crown area estimation in both approaches were compared with each other and in-situ data. The results showed that using ROI from the object-oriented provides accurate result with less run time consuming. The SVM classification algorithm with RBF and ROI obtained from segmentation were showed the best performance in comparison to other approaches.

1. Introduction

The area of tree crown is constantly changing for various reasons such as growth process, age, amount of sunlight, as well as the surface microclimate of each region (Miraki et al. 2021). In fact, crown area has a different growth rate due to the conditions of the region, season, and type of each tree unequally in different directions. Also, the crown of trees, even if they are of the same type, has a variable area, making it difficult to measure (Wu et al. 2021). On the other hand, accurate calculation of crown area is an essential parameter in physiological models (Ding et al. 2022). Ecologically, the size of the crown directly affects many plant and animal components by regulating the penetration of sunlight and precipitation into the lower layers, while maintaining forest moisture. Traditionally, the characteristics of a crown are determined by its length and width (maximum dimensions on perpendicular axes), the area and generalities of the crown shape (Shovon et al. 2022). Previous research has also highlighted the importance of measuring tree crown area (Ahongshangbam et al. 2019; Ouattara et al. 2022). Since accurate measurement of the physical characteristics of a crown depends on direct measurement of its size in all directions. Therefore, crown measurements based on data, sample diagrams and tables and their generalization to the whole region, while providing far-fetched results, also violate the assumption of error independence between observations. Therefore, the use of UAVs (Unmanned aerial vehicle) has been welcomed by providing very high spatial resolution information, the need for less infrastructure, more accurate postal harvesting of land elevations in forests, and the possibility of indirectly measuring tree characteristics (Chianucci et al. 2016; Tang and Shoa 2015).

UAVs have been used in many man-made forest research over the past few years to significantly save time, workforce, funding for various projects, and reduce the cost of maintaining and continuously Monitoring man-made forests (Matese 2020 ;Paneque-Gálvez et al. 2014) which require sufficient and continuous knowledge and application of effective methods in the

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correct diagnosis and extraction of the crown, which can be referred to as two methods of classification of pixel base and object-oriented (Region Of Interest from segmentation). SVM classification methods work based on spectral information. As the power of spatial resolution increases, classification based solely on spectral data creates many problems. One of these problems is the variability of spectral information at the level of the crown of trees due to the shadow of one part of the crown and the location of the other part facing the sun. This effect is especially pronounced in the morning or afternoon. Therefore, samples in supervised methods cannot be very effective and practical in increasing the accuracy of classification in such conditions. Also, in the forest environment, surface features such as grasslands with tree crown are very similar in terms of spectral characteristics and the amount of gray value, and practically their proper separation from each other only on the basis of spectral information with only three RGB bands (blue, green and red) Is not well possible (Li et al. 2017). Choosing an ROI (Region of Interest) is also very time consuming and fraught with error. On the other hand, the implementation of segmentation algorithm with all its advantages is a big problem and it takes a very long time (multiple times of classification), especially for images with very high spatial accuracy (such as UAV images) compared to classification, which is the use of segmentation algorithms. It faces limitations, especially if the area has a large area and spatial resolution. These limitations become even more severe, requiring a powerful processor and more time. To solve this problem and simultaneously use the advantages of segmentation and classification and eliminate the limitations (for example, lack of spectral bands and long processing time), a combination of both methods was used. In this study, we will specifically compare the estimation of the crown area with the basic and object-oriented pixel methods and compare it with the ground data in the eldarica pine man_made forest (known as Tehran pine).

2. Method

2.1. Study area

Pardisan Park of North Khorasan is located at the eighth kilometer of Bojnord-Mashhad Road (37° 28 ' 57 N "-57° 25 ' 49 " E, Zone 40 N), at an average altitude of 1080 meters above sea level. This complex is purely covered with Tehran pine (Pinus eldarica). The region is cold semi-arid according to the coupon criteria and has a relatively high slope in terms of topography (altitude range 1112 to 1037 meters). The average rainfall and its temperature according to the statistics of Bojnurd Airport Meteorological Synoptic Station (the closest station to the study area) for a period of 10 years (2011-2021) are 260 mm and 15 ° C, respectively.

2.2. Data

In this study 324 trees were selected and determined their location using GNSS. Two diameters perpendicular to each other were also used to determine the field area of the crown using a standard metal meter. Then, using the Phantom 4 Pro UAV with forward and side overlap coverage of 80% and 40% Respectively and a height of 40 meters, 952 ortho images were obtained from the study area at 14:30 local time on March 4, 2021.

2.2.1. Tree crown area estimation

Two basic and object-oriented pixel approaches were used to estimate the crown area of pine trees. In the pixel base approach, due to the knowledge of the site and having an image with high spatial resolution after selecting the ROI by the user with the appropriate scatter and number, SVM classification algorithm with RBF, Sigmoid, Polynomial and Linear functions to extract Estimation of the crown area of pine trees was performed (Lou et al. 2021).

In the object-oriented method, due to the reduction of processing time and introduction of parts, using segmentation of part of the image (not the whole image), the parts were presented as ROI to the SVM classification algorithm. In the segmentation process, according to the shape of the crown of pine trees as well as previous studies (Gu et al. 2020; Iqbal et al. 2021; Mesner and Ostir 2014) and the conditions of the study area, appropriate coefficients for segmentation parameters (Scale Parameter = 25 Pixel, Shape = 0.1, Compactness = 0.5 per pixel) was determined to accurately detect the crown of trees. Then, in the smaller fragmented image, the crown pieces were extracted as a training sample in separate layers with pixel format to distinguish them from other existing features (shadow and soil). Then, by comparing the area of tree canopies, the execution time of the algorithm and comparing it with direct field perceptions for both SVM approaches with Linear, Sigmoid, Polynomial and RBF functions were discussed. Finally, by introducing the crown layer as the ROI of the image, the SVM classification algorithm was implemented and finally in both approaches, the error matrix was calculated.

3. Results

Pine trees with different crown areas were directly measured in the field and photographed by UAV. summarizes the field measurements in the study area shown in “Table 2”. According to the results, in general, the use of ROI from segmentation and its use for classification has given better results in the extraction of crown pixels and also has the closest crown area to the area obtained from field data “Fig. 1” and “Table 3”.

4. Discussion

Based on the data in “Table 3”, the identification of the general shape of the crown, followed by the estimation of the area in the segmentation, has been done with better accuracy. Unlike the classification methods used in this study (SVM), in segmentation, three parameters, scale, compactness and shape, are simultaneously involved in selecting a set of pixels to be placed in a single segment.

Table 2. Summary of statistical characteristics of the crown area of 324 Tehran pine trees Estimated UAV events

Characteristic	MIN	Max	Mean	STD	CV
Height (meters)	0.5	13.1	6.6	2.6	38.9
Small diameter of the crown	1.0	7.8	4.3	1.1	25.4
Large crown diameter (meters)	2.3	11.6	5.8	1.4	23.4
Crown area (square meters)	0.8	49.9	15.9	7.9	49.7

Table 3. Classification results with ROI resulting from user selection and ROI derived from object-oriented method

		Kappa coefficient (%)	Overall accuracy (%)	User accuracy (%)	Product accuracy (%)	Omission	Commission (%)	Crown Area(m²)	Time of classification and selection ROI (min)	Field crown area (m²)	Number of training data	Number of testing data
ROI from User	RBF	75	82	79	81	21	19	4297	83	5106	11731	1523
	Sigmoid	73	80	78	72	22	28	4272	86			
	Polynomial	67	73	69	74	31	26	3978	93			
	linear	61	68	66	70	34	30	3681	72			
ROI from Segmentation	RBF	93	98	92	96	8	4	5021	27	5106	10419	894
	Sigmoid	91	92	89	93	11	7	4942	33			
	Polynomial	88	91	86	89	14	11	4847	39			
	linear	79	86	83	84	17	16	4673	21			

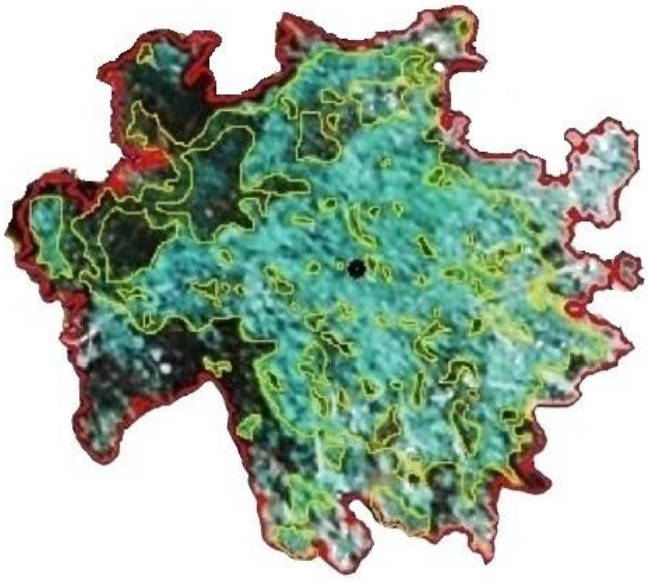

Figure 1. Extraction of pine tree crown with object-oriented approach (red border), pixel base (yellow border), and center of tree (black point)

Each of these parameters can weaken the use of each other in solve single parameter mode, which leads to higher efficiency. The effect of segmentation capabilities in this study, in which pixels with close gray levels (crown and grass on the ground) and similar spectra in a phenomenon is more obvious.

The use of segmentation, despite the effect of shadow on the crown and the angle of sunlight on the surface of the tree crown (facing the sun or behind it) has separated the crown well and has been more stable in recognizing the main shape of the tree and its shadow effect. The existence of empty space between the branches of a tree, which is originally part of the crown, is not considered part of the crown in the classification, but is correctly part of the crown area in the segmentation "Fig. 1". The results of this study also showed that the use of segmentation method works well even with a small number of bands (RGB), while the use of segmentation, especially in features with varying gray value(such as crown and shadow) requires more bands that cost, time And will result in heavier processing. In addition, the time-consuming selection of ROIs and the selection of a sufficient number of pixels for which there is no specific rule are among the reasons for the lower accuracy of classification in the pixel basic approach compared to the object-oriented approach "Table 3". According to the information in "Table 3", the classification accuracy with the ROI resulting from segmentation, with a smaller number of pixels, has increased the "overall accuracy" and "kappa coefficient". Also, processing time was measured in completely similar system modes in both approaches, which results in a significant reduction in time (even up to 60%) when using segmentation ROIs for classification. Examining the accuracy of Omission and Commission in "Table 3", it can be seen that the use of SVM method with RBF function in ROI mode resulting from segmentation has the least difference with the area obtained from field data collection compared to other methods used in "Table 3". Only 8% of the pixels are not in the crown category (Omission). While 4% of the pixels belong to another class in the crown class (Commission).

5. Conclusion

Although having a point cloud can easily distinguish the crown of trees, but sometimes due to high cost, technical limitations and the impossibility of providing a three-dimensional model in inappropriate forward and side overlap coverage, the point cloud is not available to everyone. Therefore, it is suggested to use the ROI obtained from segmentation to classify the crown in RGB images. However, the purpose of the work in choosing the final method can make a difference.

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