6th Intercontinental Geoinformation Days

igd.mersin.edu.tr

Investigation of linear and logarithmic regression between measured and calculated parameters of Eldarica pine tree

Ali Hosingholizade *[1]

[1]*University of Tehran, Department of Remote Sensing and GIS, Tehran, Iran*

Keywords
UAV
Segmentation
Classification
Crown Area
Bojnord

Abstract

Man-made forests are created with various goals, including reducing the pressure on natural forests. Therefore, the knowledge of the status of their quantitative characteristics for planning and achieving primary goals has always been of interest to the managers of these types of forests. In this research, field data collection of parameters such as height, DBH and crown area was done with Phantom 4 UAV RGB images (2 Cm), Total Station TS02 (7″) and standard metal meter(1mm). Then it was obtained by calculating the parameters with the help of paired images (crown area) and point cloud (Height and Diameter at breast height). In the next step, two-by-two linear and logarithmic regression relationships were created between H, DBH and crown area parameters, and the value of R^2 was also obtained. The results showed that linear regression is better than logarithmic regression. Also, the amount of R^2 between DBH and H parameters in two cases of data from field measurements (R^2=0.75) and data from calculations (R2=0.83) gave better results than the comparison of other parameters. Therefore, it is possible to use linear regression equations between DBH and H in very few statistics, similar environmental conditions and no need for very high accuracy.

1. Introduction

Studying the physical quantities of trees provides the possibility of optimal forest management to achieve the desired structure. Among these physical quantities are the diameter at breast height (DBH), height, crown area (the largest diameter and the perpendicular to it for calculation area), which in addition to the importance of each one, examining the relationship between them is importance (Liao et al. 2022; Tienaho et al. 2022). For example, DBH, the crown area and the height of the tree are among the variables that are measured in order to estimate forest inventory, biomass, forest simulation, tree growth theory, carbon estimation and volume measurement. All of which require accurate models between the physical parameters of the tree. (Lou et al. 2022). In forest statistics, tree height is often estimated from the measured diameter of the tree at breast height. The diameter of the tree can be measured easily and at low cost. Measuring tree height is relatively more difficult and costly (Moreira et al. 2021; Iizuka et al. 2017). Therefore, models that are measured exclusively based on diameter have a great impact on cost. With the importance of breast diameter as the main biometric variable of forest trees, its study has particular importance (Nazariani et al. 2021). This variable has a high correlation with the variables of height, volume and other tree sizes and is considered an important factor in the study of these characteristics (Arabatzis and Burkhart. 1992). Another important physical parameter that is used in modeling the growth and performance of forest is the crown area, which is highly correlated with tree growth and its accurate measurement in the forest, especially for adult trees are challenge (Hosingholizade et al. 2022). In order to solve these challenges such as time-consuming and expensive in large areas, the use of Unmanned aerial vehicle (UAV) paired images and the resulting point cloud can solve the problems (Hosingholizade et al. 2022). Therefore, the evaluation of single trees in forest is highly considered for the use of UAV technology in large-scale forests. These separations are based on single trees in coniferous forests with good accuracy (Iqbal et al. 2021). Based on, different equations have been developed between the physical parameters of

* **Corresponding Author**

*(a.hosingholizade@ut.ac.ir) ORCID ID 0000–0001–5286–1361

Cite this study

Hosingholizade, A. (2023). Investigation of linear and logarithmic regression between measured and calculated parameters of Eldarica pine tree. Intercontinental Geoinformation Days (IGD), 6, 1-4, Baku, Azerbaijan

the tree, but since the growth of different parts of a tree depends on different parameters, such as soil type, moisture, type and species of tree, amount of sunlight, rainfall, temperature and human factors (pollutants). (Jones et al. 2020; D'Odorico et al. 2021). Therefore, a general equation cannot be used for all conditions and species across the globe. Nowadays, the use of local equations and its development according to the existing conditions in order to study more and more accurately It is widely used. (Goodbody et al. 2017).

Also, continuous imaging and parameter calculations are not economical for small levels and it also results in limitations of local flights and permits. On the other hand, the lack of flight teams and specialist forces for image processing, sampling, quick and low count investigations (very few number), makes the use of regression equations still justified despite the capabilities of UAVs. Therefore, in this research, while using paired images of UAVs and the resulting point cloud and considering the ground measurements, we tried to establish equations using the appropriate in SPSS V.26 between physical parameters such as crown area and diameter. so that these equations can be used according to similar environmental conditions in other places or small number of investigations. “Figure 1” shows the process.

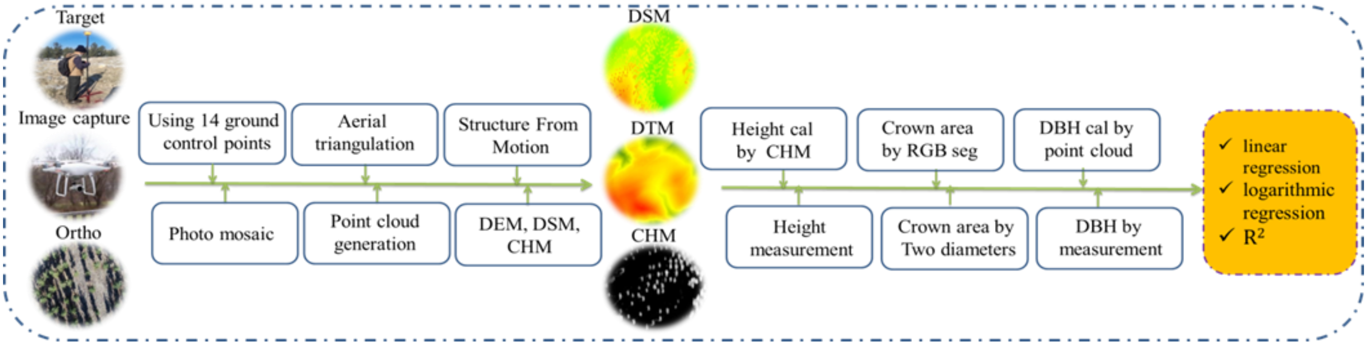

Figure 1. Workflow of the study

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 topography (1112 to 1037 meters). The average rainfall and its temperature according to the statistics of Bojnord 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. Field data collection and processing

In this research, 324 Eldarica pine trees were registered using dual-frequency GPS Raymand 3GB with the definition of horizontal (0.5 cm) and vertical (1 cm) accuracy thresholds. Then, the direction of the reference ground and the better construction of the model were marked on the ground from 14 control points with proper dispersion and visibility from all directions and recorded accurately with a dual-frequency GPS. In the next step, 952 images were recorded with Phantom 4 UAV with 90-degree angles as Crossing with 80 and 40 percent longitudinal and sidelab coverage and at a height of 40 meters from the ground. Due to restrictions on presence in the area and permits, the flight took place at 14:30 local time (11:30 UTC) on March 4, 2021. For field data collection, the height of all the trees was measured using a TS02 TotalStation (accuracy of 7 seconds of degrees). Finally, by using a standard metal meter, the diameter at breast height and the two perpendicular diameters of the crown (to calculate the area with the ellipse formula) were accurately measured. After field imaging and data collection, a three-dimensional model of the area and a mosaic image was obtained using the PIX4D software using the SFM algorithm. To calculate the area of the crown, segmentation of the RGB image of the region using parameters Compactness, Scale and Shape in Ecognition V9.1 was used. By generating point cloud from RGB images, products such as Digital Terrain Models (DTM), Digital Surface Models (DSM) and from the difference between these two Canopy Height Models (CHM) (height of each tree) were obtained by using Cloudcompare v11. Then, the diameter at breast height (height of 1.30 cm) was calculated on the Trimble Business Center (TBC) software. Finally, the calculated and measured data were statistically analyzed in SPSS V.26 software.

3. Results

In this research, the number of 324 pine trees in Tehran with different diameters and heights according to the difference in the year of their planting were directly measured in the field. “Table 1” shows a summary of field measurements. Torres-Sanchez et al. (2018) also studied 325 tree bases in estimating the characteristics of single almond trees on UAV data, which is similar to the number of samples in the present study. As can be seen, the studied pine trees had a relatively diverse range of diameter and height, and this issue plays an important role in establishing equations and evaluations. “Table 2” also shows the linear and logarithmic regression equations between the parameters of tree height (H), DBH and crown area.

Table 1. Summary of statistical characteristics of the crown area of 324 pine trees Estimated UAV events

Method	Characteristic	Min	Max	Mean	STD	CV (%)
Field	Height (meter)	0.54	13.07	6.62	2.60	38.91
	DBH (meter)	0.10	0.62	0.37	0.11	30.29
	Crown area (square meter)	0.81	49.94	15.95	7.92	49.74
Calculation	Height (meter)	0.68	13.14	6.78	2.56	37.86
	DBH (meter)	0.11	0.72	0.44	0.13	30.96
	Crown area (square meter)	5.85	44.35	17.22	6.43	37.01

Table 2. Linear and logarithmic equations by using Field (F) and calculated (Cal) data

Parameter	Linear Equation	R^2	Logarithmic Equation	R^2
H(F) < > DBH(F)	y = 0.0379x + 0.118	0.75	y = 0.1724ln(x) + 0.062	0.67
H(F) < > Crown area(F)	y = 1.3904x + 6.552	0.21	y = 5.9275ln(x) + 5.198	0.16
DBH(F) > Crown area(F)	y = 0.0105x + 0.204	0.52	y = 0.1469ln(x) - 0.016	0.51
H(Cal) < > DBH(Cal)	y = 0.0479x + 0.110	0.83	y = 0.2302ln(x) + 0.018	0.74
H(Cal) < > Crown area (Cal)	y = 1.3583x + 8.008	0.29	y = 6.055ln(x) + 6.241	0.22
DBH(Cal) < > Crown area(Cal)	y = 0.0159x + 0.161	0.63	y = 0.2887ln(x) - 0.367	0.60

4. Discussion

As shown in “Table 1”. The physical parameters (DBH, H, crown area) resulting from calculations generally have lower standard deviation (STD) and Coefficient of variation (CV) compared to field measurements, which indicates less dispersion of this type of data. Among the parameters, the DBH standard deviation is lower than the height and crown area parameters, which means that the field measurement as well as calculations in DBH have been done more accurately than the height and crown area, which can cause different reasons. One of these reasons is direct access to the tree trunk. In other words, calculation of height and crown area is indirect, which can be the correct sign error for measurement, not taking the staff to calculate the length of the diameters (for use in area estimation) and the total station level error to measure the height. Regarding the height, as is clear in “Table 1”, it has less standard deviation than the crown area, which measurement with total station and marking is more accurate than visually finding the dimensions and border of the crown and measuring it can be one of the reasons. Also, the values of statistical parameters such as: Max, Min and Mean indicate the diversity in the physical parameters of pine trees in the study area.

By examining the data in “Table 2”, in general, it can be seen that in the Eldarica pine trees in the study area, in the linear regression mode, the R2 value was higher than the logarithmic mode. In simpler words, in the linear mode, the relationship between the variables has been associated with a higher correlation. Of course, this correlation and changes in it were not the same for all parameters. For example, by examining the relationship between DBH and H parameters, it has the highest R2 in linear (R2=0.75) and logarithmic (R2=0.67) data for direct field measurements. The same advantage exists when using data from calculations, that is, in the case of using calculation data, the R2 value for DBH and H parameters has a higher value. On the other hand, the amount of R2 in parameters H and crown area in two modes of direct field data collection and computational data has the lowest correlation for pine trees in the region in linear mode (R2=0.16 and R2=0.21). logarithmic result is (R2=0.22 and R2=0.29).

5. Conclusion

Estimation of physical parameters in man-made forests is an important goal for applications using UAVs. However, the use of UAVs and their accuracy in estimating physical parameters have been proven many times in forest studies. In some cases, due to the small number of trees, the use of UAV is not economical and even in some areas, it is not possible to issue a flight permit. Therefore, quick and low-cost evaluation so that even non-experts can collect data is becoming more necessary and the use of regressions has a special value. Based on the obtained results, the use of linear regression in estimating the physical parameters of Eldarica pine trees has brought better results. Also, the use of DBH and H parameters in two modes of direct field data collection and the data obtained from calculations has a much higher correlation rate than other physical parameters. Therefore, it is suggested to use these equations between DBH and H to estimate parameters (linear regression) for areas with soil, weather and other parameters similar to the studied area.

Acknowledgement

The authors of the study are grateful to the General Directorate of Environmental Protection of North Khorasan province. Also, part of the costs of this research has been provided through the plan number 4003393 approved by the Fund for Support of Researchers and Technologists of the country.

References

Arabatzis, A. A., & Burkhart, H. E. (1992). An evaluation of sampling methods and model forms for estimating height-diameter relationships in loblolly pine plantations. Forest science, 38(1), 192-198. https://doi.org/10.1093/forestscience/38.1.192

D'Odorico, P., Schönbeck, L., Vitali, V., Meusburger, K., Schaub, M., Ginzler, C., & Ensminger, I. (2021). Drone-based physiological index reveals long-term acclimation and drought stress responses in trees. Plant, Cell & Environment, 44(11), 3552-3570. https://doi.org/10.1111/pce.14177

Fradette, O., Marty, C., Tremblay, P., Lord, D., & Boucher, J. F. (2021). Allometric equations for estimating biomass and carbon stocks in afforested open woodlands with black spruce and jack pine, in the eastern canadian boreal forest. Forests, 12(1), 59. https://doi.org/10.3390/f12010059

Goodbody, T. R., Coops, N. C., Marshall, P. L., Tompalski, P., & Crawford, P. (2017). Unmanned aerial systems for precision forest inventory purposes: A review and case study. The Forestry Chronicle, 93(1), 71-81.

Hosingholizade, A., Erfanifard, Y., Alavipanah, S. K., Latifi, H., & Jouybari-Moghaddam, Y. (2022). An assessment of support vector machines for crown delineation of pine single trees on unmanned aerial vehicle imagery. Intercontinental Geoinformation Days, 4, 17-20.

Hosingholizade, A., Erfanifard, Y., Alavipanah, S. K., Latifi, H., & Jouybari Moghaddam, Y. (2022). Comparison of unmanned aerial vehicle (UAV) RGB imagery and point clouds in crown area estimation of individual trees within pine (Pinus eldarica) man-made forests. Journal of RS and GIS for Natural Resources.

Iizuka, K., Yonehara, T., Itoh, M., & Kosugi, Y. (2017). Estimating tree height and diameter at breast height (DBH) from digital surface models and orthophotos obtained with an unmanned aerial system for a Japanese cypress (Chamaecyparis obtusa) forest. Remote Sensing, 10(1), 13. https://doi.org/10.3390/rs10010013

Iqbal, I. A., Osborn, J., Stone, C., & Lucieer, A. (2021). A comparison of als and dense photogrammetric point clouds for individual tree detection in radiata pine plantations. Remote Sensing, 13(17), 3536. https://doi.org/10.3390/rs13173536

Jones, A. R., Raja Segaran, R., Clarke, K. D., Waycott, M., Goh, W. S., & Gillanders, B. M. (2020). Estimating mangrove tree biomass and carbon content: a comparison of forest inventory techniques and drone imagery. Frontiers in Marine Science, 6, 784. https://doi.org/10.3389/fmars.2019.00784

Liao, K., Li, Y., Zou, B., Li, D., & Lu, D. (2022). Examining the Role of UAV Lidar Data in Improving Tree Volume Calculation Accuracy. Remote Sensing, 14(17), 4410. https://doi.org/10.3390/rs14174410

Lou, X., Huang, Y., Fang, L., Huang, S., Gao, H., Yang, L., ... & Hung, I. K. (2022). Measuring loblolly pine crowns with drone imagery through deep learning. Journal of Forestry Research, 33(1), 227-238. https://doi.org/10.1007/s11676-021-01328-6

Moreira, B. M., Goyanes, G., Pina, P., Vassilev, O., & Heleno, S. (2021). Assessment of the influence of survey design and processing choices on the accuracy of tree diameter at breast height (DBH) measurements using UAV-based photogrammetry. Drones, 5(2), 43. https://doi.org/10.3390/drones5020043

Nazariani, N., Hamidi, S. K., & Mansour Samaei, R. (2021). Investigating Diameter-Height Models of Fagus and Carpinus betulus Forest in Area 40 A of Noshahr (Mazandaran). Natural Ecosystems of Iran, 12(1), 70-83.

Tienaho, N., Yrttimaa, T., Kankare, V., Vastaranta, M., Luoma, V., Honkavaara, E., ... & Saarinen, N. (2022). Assessing Structural Complexity of Individual Scots Pine Trees by Comparing Terrestrial Laser Scanning and Photogrammetric Point Clouds. Forests, 13(8), 1305. https://doi.org/10.3390/f13081305

Torres-Sanchez, J., de Castro, A. I., Pena, J. M., Jimenez-Brenes, F. M., Arquero, O., Lovera, M., & Lopez-Granados, F. (2018). Mapping the 3D structure of almond trees using UAV acquired photogrammetric point clouds and object-based image analysis. Biosystems engineering, 176, 172-184. https://doi.org/10.1016/j.biosystemseng.2018.10.018