AN APPROXIMATE METHOD OF EVALUATING THE DISTANCES IN SOME AERIAL IMAGES

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Abstract: *Regarding the aerial images used in the fields in which a very high accuracy of the evaluated parameters is not necessary, approximate methods of determining the size of the photographed elements can be used. The present paperwork represents a study regarding the distance evaluation between two points in relation with the height of the camera, based on the theory of regression. Following the analysis of several images taken from different heights of 25-70 m, high values of the correlation coefficient were determined as well as the value sig f. of 0.002 respectively F = 414.7, for the inverse function, which indicated a higher confidence level in the functional model.*

***Key words**: aerial images, forest vegetation, theory of regression*

INTRODUCTION

The UAV technology is currently experiencing a spectacular development in the most varied practical fields. This is determined by the fast progress of research both in the field of light aircrafts used in the imagistic field and in the field of aircrafts taking photos [1]. Aerial images represented a visual support allowing the evaluation of the state of crops [6-8], forests [13] landscape changes [4,9] or in fulfilling the standards required in the field of precision agriculture [2].

The working parameters are essential for the quality of the captured image. The height from which the images were taken induces important imagistic modifications. Therefore, the image of an arable land was analyzed from a morphological point of view by using the theory of fractals based on the photographs taken from various altitudes [12]. Specific techniques were studied regarding inclination, altitude, exposure time in making the photos in order to create some specific frames [10,11,15].

There are fields in which the determination precision of some imagistic characteristics is very important, e.g. the research in the field of geomatics, technical projects of urban development and regional planning etc. and which are not included in this current study.

However, the aerial images can also be used in fields that are less pretentious from the point of view of calculation precision. For example, the size evaluation of certain species of trees, approximating the surface destined for the crops of plants, the approximation of elements in some landscaping projects used for private purposes etc. These aspects regarding distance approximation, where this is allowed, represents the objective of this study. Specifically, we refer to the determination of the regression function in order to describe the distance between two points in site as they appear in the photographic images, depending on the height of the camera located on a drone.

MATERIALS AND METHODS

The study starts from the images taken with UAV equipment – a Phantom 3 Standard type drone. The images refer to a land surface with forest vegetation in Timis County of Romania.

The photos were made by moving the drone on a vertical trajectory above a ground control point – GCP, from a height of 25 m, 30 m, 35 m, 40 m and 70 m. Given a segment of L length in the plane, the variation of its apparent length in the images taken from different heights, h_i, is proportional with the angle α (figure 1).

A schematic representation of the above problem is given in figure 1 and the trigonometric calculations will be made in the obtained right triangle.

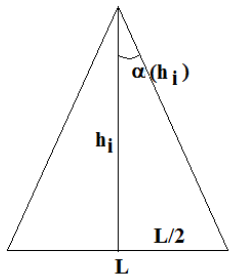


Figure 1. Schematic representation of the measured elements

Therefore, we have: $tg\alpha(h_i) = \frac{L/2}{h_i} \Rightarrow \alpha(h_i) = arctg\frac{L}{2h_i}$. The problem here is to determine a regression function to approximate the trajectory defined above. In this regard, we propose a regression function with a simplified expression, $y(h) = b_0 + b_1 \cdot \frac{1}{h}$, the inverse function according to the SPSS terminology. This function, even though it has an expression different from the arctangent function, however, its graph has a similar trend on certain portions, at the same time, having the advantage to be easily determined from a statistical point of view. Briefly, it reduced by linearization to a regression line with the following well-known expression:

$$L(h) = b_0 + b_1 \cdot \frac{1}{h} \Leftrightarrow L(h) = b_0 + b_1 \cdot H,\ H = \frac{1}{h}$$

The coefficients can be determined by the relations:

$$\begin{cases} b_1 \sum_{i=1}^{n} H_i^2 + b_0 \sum_{i=1}^{n} H_i = \sum_{i=1}^{n} H_i L_i \\ b_1 \sum_{i=1}^{n} H_i + b_0 n = \sum_{i=1}^{n} L_i \end{cases}$$

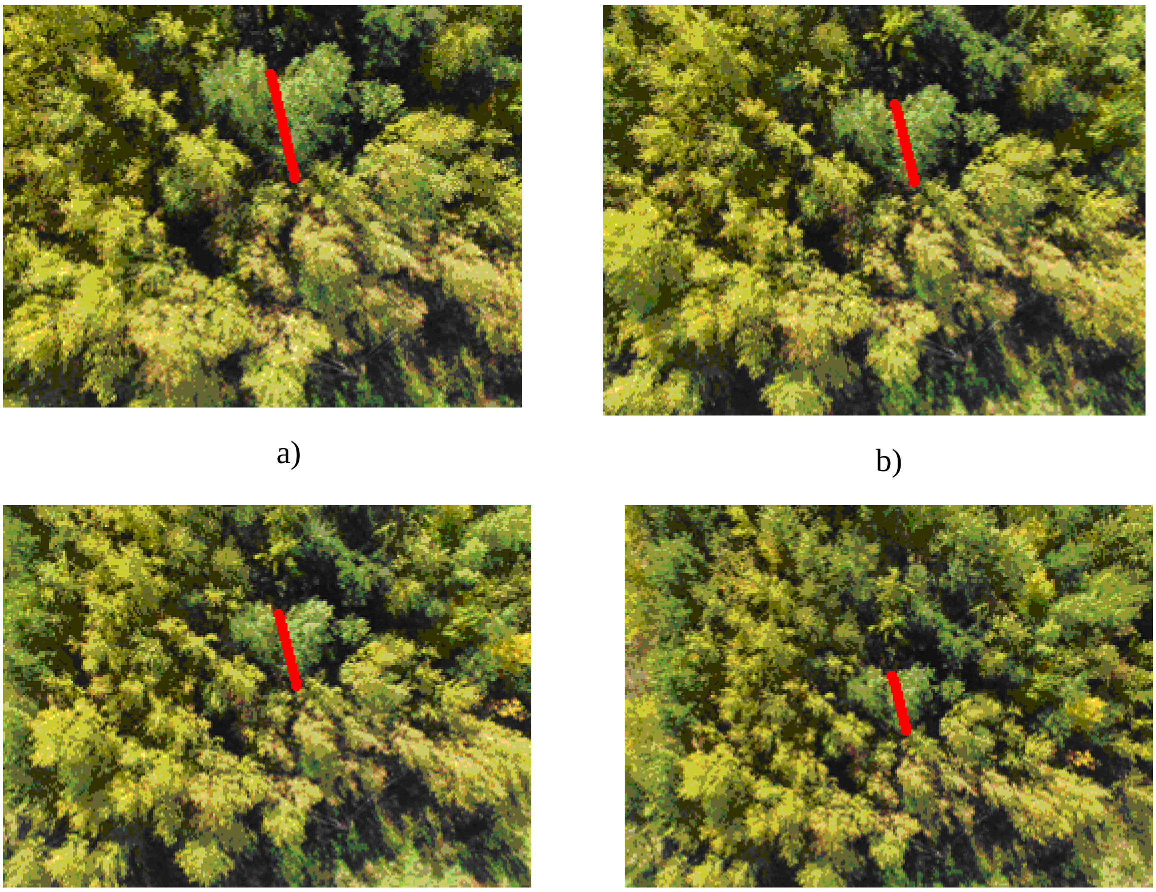
The equation system has an immediate solving using the expressions below given by Cramer's rule.

$$b_1 = \frac{\begin{vmatrix} \sum_{i=1}^{n} H_i L_i & \sum_{i=1}^{n} H_i \\ \sum_{i=1}^{n} L_i & n \end{vmatrix}}{\begin{vmatrix} \sum_{i=1}^{n} H_i^2 & \sum_{i=1}^{n} H_i \\ \sum_{i=1}^{n} H_i & n \end{vmatrix}}, \quad b_0 = \frac{\begin{vmatrix} \sum_{i=1}^{n} H_i^2 & \sum_{i=1}^{n} H_i L_i \\ \sum_{i=1}^{n} H_i & \sum_{i=1}^{n} L_i \end{vmatrix}}{\begin{vmatrix} \sum_{i=1}^{n} H_i^2 & \sum_{i=1}^{n} H_i \\ \sum_{i=1}^{n} H_i & n \end{vmatrix}}$$

In order to determine the coefficients, the SPSS application was used.

RESEARCH RESULTS

The images taken were those of the above figure. Practically, the drone was positioned on a fixed axis, perpendicular to the ground's plane and the height was variable.



a) b)

c) d)

Figure 2. Images taken from various heights

Carrying out measurements for each photo and keeping the same photographic format, the data of the table below are obtained.

Table 1

Relation between the apparent length of a segment and the height from which the image was taken. Empirical values

Crt. no (i)	Height (h)	Apparent length (L)
1	25	52
2	30	40
3	35	34
4	40	28

Using the SPSS application in order to estimate the functions known to have a similar trend, the data of table 2 were obtained.

Table 2

Estimation of the functional model for describing the empirical values

	rsq	Sig f	F	b_0	b_1
Linear	0.966	0.017	56.3		
Inverse	0.995	0.002	414.7	-11.497	1575.884
Quadratic	0.994	0.076	87.0		
Cubic	0.994	0.076	87.0		
Exponential	0.990	0.005	201.1		

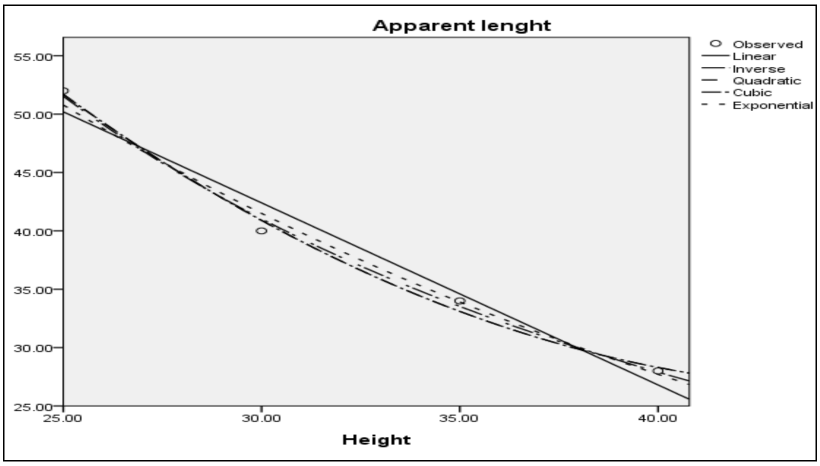


Figure 3. The graph (SPSS) describing the estimation of the functional model height (m) – apparent length (mm)

Even though the values of the correlation coefficient are high in each case, however, the value sig f. of 0.002 respectively F = 414.7, for the inverse function, indicates a higher confidence level in this functional model.

In table 3 there are the values estimated by the regression model using the inverse function. Moreover, in table 4, there were calculated by simulation for various values of heights the values related to the apparent lengths of the initial segment.

The variation of some parameters from the digital images together with the height were reported by Sala et al., (2017) in the study and the characterization of an arable land by fractal analysis. The fractal dimensions were varied in relation with the H of images taken, within the working interval 2-30 m of height. The variation of the characterization parameters of the images based on the fractal dimensions was also noticed by Perry et al. (2008). They recorded the increase of the fractal value together with the increase of the distance compared to the studied subject.

Table 3

Values estimated via the regression model using the inverse function, for the apparent lengths, for the values of the heights at which the images were taken

Height (h)	Apparent length (L)	Apparent length (L*)
25 m	52 mm	51.5 mm
30 m	40 mm	41.3 mm
35 m	34 mm	33.5 mm
40 m	28 mm	27.9 mm

Table 4

Values estimated via the regression model. Simulation for multiple values of the heights at which the images were taken

h (m)	L* (mm)	h (m)	L*(mm)	h (m)	L* (mm)	h (m)	L* (mm)
22	60.1	42	26.0	62	13.9	82	7.7
24	54.2	44	24.3	64	13.1	84	7.3
26	49.1	46	22.8	66	12.4	86	6.8
28	44.8	48	21.3	68	11.7	88	6.4
30	41.0	50	20.0	70	11.0	90	6.0
32	37.7	52	18.8	72	10.4	92	5.6
34	34.9	54	17.7	74	9.8	94	5.3
36	32.3	56	16.6	76	9.2	96	4.9
38	30.0	58	15.7	78	8.7	98	4.6
40	27.9	60	14.8	80	8.2	100	4.3

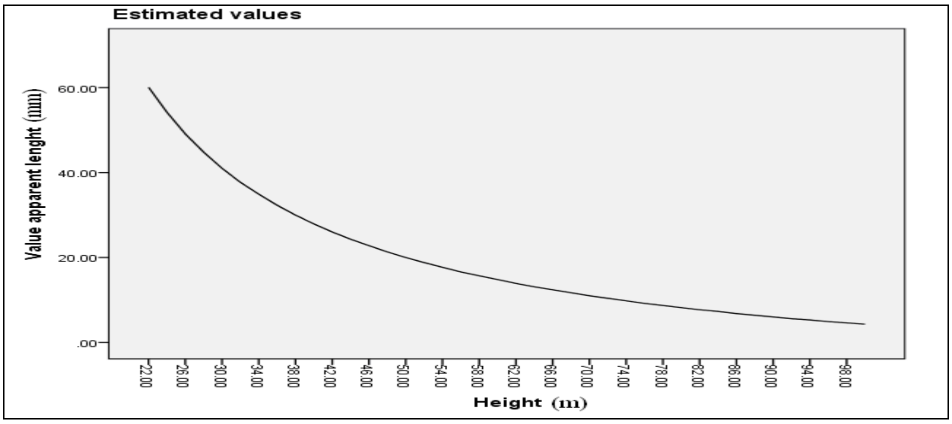


Figure 3. Values estimated via the regression model. Simulation for multiple values of the heights at which the images were taken

CONCLUSIONS

If no high precision is necessary in order to determine the studied elements, the approximate methods are useful due to the simplification of the related calculations.

At a glance, we can notice some possible applications: determination of the height from which the images were taken depending on the apparent length of a segment, respectively vice versa, the possibility of programming the height for taking photos in a certain desired format. Likewise, the characteristics of some images can be predicted depending on height when technically it is not possible to exceed a certain altitude. Obviously, these elements can be determined only following the initial determination of a set of empirical data of those presented above.

REFERENCES

[1]. ABER J. S., MARZOLFF I., & RIES J., 2010, Small-format aerial photography: Principles, techniques and geoscience applications, Elsevier

[2]. CANDIAGO, S., REMONDINO F., DE GIGLIO M., DUBBINI M., & GATTELLI, M., 2015, Evaluating multispectral images and vegetation indices for precision farming applications from UAV images. Remote Sensing, *7*(4), 4026-4047

[3]. ftp://public.dhe.ibm.com/software/analytics/spss/documentation/statistics/21.0/en/client/Manuals/IBM_SPSS_Statistics_Core_System_Users_Guide.pdf

[4]. GERARD F., PETIT S., SMITH G., THOMSON A., BROWN N., MANCHESTER S., ... & BOLTIZIAR M., 2010, Land cover change in Europe between 1950 and 2000 determined employing aerial photography. Progress in Physical Geography, 34(2), 183-205

[5]. GRENZDÖRFFER G. J., ENGEL A., TEICHERT B., 2008, The photogrammetric potential of low-cost UAVs in forestry and agriculture. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 31(B3), 1207-1214

[6]. HERBEI M. SALA F., BOLDEA M., 2015, Relation of normalized difference vegetation index with some spectral bands of satellite images. AIP Conference Proceedings 1648: 670003-1 – 670003-4

[7]. HERBEI M.V., SALA F., BOLDEA M., 2015, Using mathematical algorithms for classification of LANDSAT 8 satellite images AIP Conference Proceedings 1648: 670004-1 – 670004-4

[8]. HERBEI M.V., SALA F., 2015, Use landsat image to evaluate vegetation stage in sunflower crops. AgroLife Scientific Journal 4(1): 79-86

[9]. MIRIJOVSKY J., & BRUS J., 2011, Utilization of a small-format aerial photography from drone pixy concept in the evaluation of the landscape changes. 11th International Multidisciplinary Scientific GeoConference SGEM2011, 2, 345-352

[10]. PETRIE G., 2009, Systematic oblique aerial photography using multiple digital cameras. Photogrammetric Engineering & Remote Sensing, 75(2), 102-107

[11]. QUILTER M. C., & ANDERSON V. J., 2000, Low altitude/large scale aerial photographs: A tool for range and resource managers. Rangelands Archives, 22(2), 13-17

[12]. SALA F., HERBEI M.V., RUJESCU C., 2017, Morphology characterization of a plowed land through fractal analysis, Volume 21(1), 165- 173, 2017 Journal of Horticulture, Forestry and Biotechnology www.journal-hfb.usab-tm.ro

[13]. SUÁREZ J. C., ONTIVEROS C., SMITH S., & SNAPE S., 2005, Use of airborne LiDAR and aerial photography in the estimation of individual tree heights in forestry. Computers & Geosciences, 31(2), 253-262

[14]. TURNER D., LUCIEER A., & WATSON C., 2012, An automated technique for generating georectified mosaics from ultra-high resolution unmanned aerial vehicle (uav) imagery, based on structure from motion (sfm) point clouds. Remote sensing, 4(5), 1392-1410

[15]. VERHOEVEN G. J., 2009, PROVIDING AN ARCHAEOLOGICAL BIRD'S-EYE VIEW–AN overall picture of ground-based means to execute low-altitude aerial photography (LAAP) in Archaeology. Archaeological Prospection, 16(4), 233-249