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DETERMINATION OF HYDROGRAPHY ELEMENTS USING IMAGE INTERPRETATION AND PROCESSING TECHNIQUES

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Abstract: *Determining the geometric elements required for the probabilistic calculation of flood bands for watercourses within a hydrographical basin can be achieved by extracting information from remote sensing digital recordings. Given the increasing frequency of extreme hydrological phenomena, the use of data obtained through aerial remote sensing offers the advantage of rapidly determining the geometric characteristics needed to generate profiles for the probabilistic calculation of flood bands for all watercourses within a hydrographical basin.*
Keywords: Digital photogrammetric images, histogram analysis, determining hydrography elements

1. Structure of digital images

An image obtained with a digital photogrammetric camera is a two-dimensional data structure, a matrix composed of pixels. Each pixel P_{ij} is associated with three values: the row coordinate Li the column coordinate C_j, and the physical measurement recorded by a sensor in that pixel within a given wavelength range LS (ij).

If the sensor has k spectral bands, then the image consists of k matrices called channels. In this case, a pixel P_{ij} has coordinates Li, C_j and k associated physical measurements: LS1(ij), LS2(ij) ..., LSk(ij), called radiometric intensities. The radiometric intensities of a channel are numerical values ranging from 0 to 255, i.e., 256 =2^8 possible values (8-bit encoded image) [1].

Visualizing a digital image involves associating a colour with each radiometric value. In black and white spectrum visualization, black is influenced by the minimum intensity (value zero), while white is influenced by the maximum intensity (value 255), constituting an ordered range of gray levels representing intermediate intensity values. The value of each image pixel (the gray level of each pixel) is the measure of that point's intensity.

2. Image processing and analysis

For applications based on digital image interpretation, it is necessary to determine the distribution of pixels in the image according to their radiometric intensity or histogram. Thus, the histogram is a statistical representation of the image without considering the pixel locations within the image. For an image I of M × N pixels, and L grey levels, the histogram is defined as the probability of occurrence in the image of the different possible gray levels, according to the formula:

$$h(k)=\frac{1}{MN}\sum_{M=0}^{M-1}\sum_{N=0}^{N-1}\delta(k-I(m,n))$$

$$k=0,1,...,L-1$$

being a probability function, the histogram meets the normalization condition:

$$\sum_{k=0}^{L-1} h(k) = 1$$

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The cumulative histogram is the distribution function of the random variable representing the gray level of an image, i.e., it represents the probability that a pixel in the image has a grey level less than or equal to a set threshold:

$$H(k)=\sum_{a=0}^{k} h(a)$$

$$k=0,1,...,L-1 \quad [1]$$

If the grey level in an image sufficiently characterizes the elements of interest, then the image's histogram will present a structure of dominant modes, which are ranges of grey levels that appear with higher probability. A mode is a maximum of the histogram representing characteristic values of planimetric details within the image (water, land, shadows, etc.) [2].

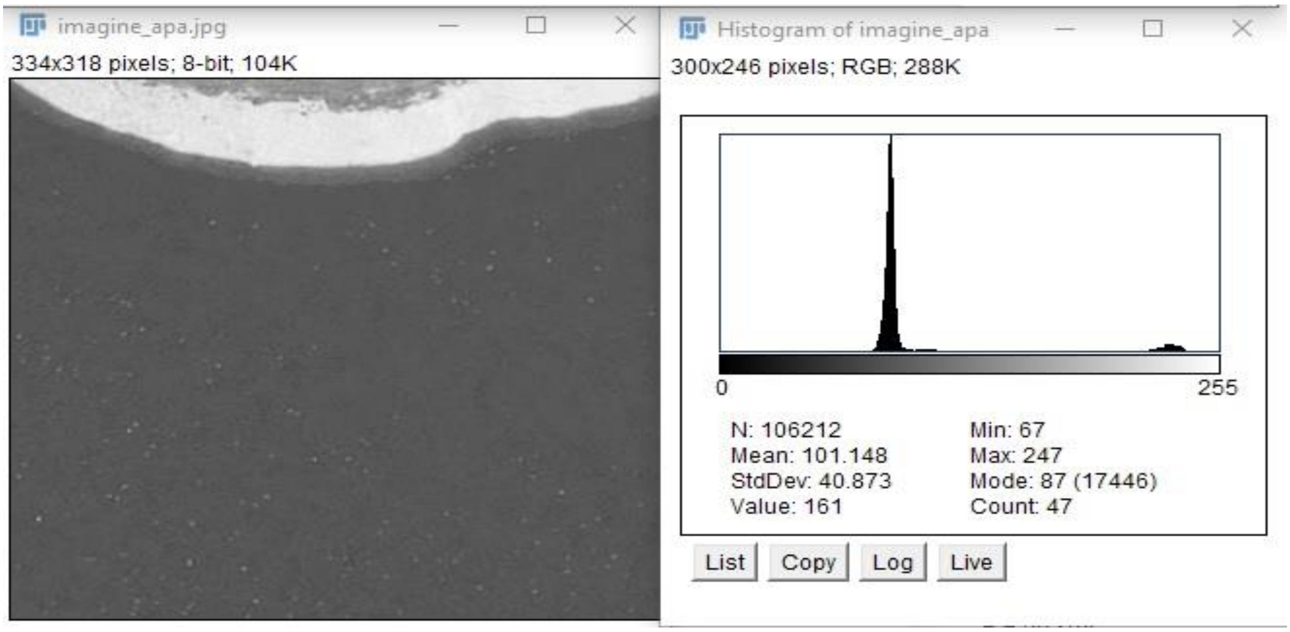

Fig. 1. Histogram of an image with two dominant modes (water, land)

For good identification of the elements of interest within the image, qualitative improvement of the image is necessary through dynamic adaptation techniques that increase the contrast of the information contained in the image by adjusting the histogram. Dynamic adaptation based on the histogram allows for the best separation of values representing homogeneous radiometric themes in the image or the approximation of marginal values corresponding to heterogeneous radiometric themes. Transformations applied to histograms are usually linear, meaning there is a direct relationship between the original image pixel intensities and their intensities in the resulting image [3].

3. Determining hydrography elements

From the perspective of applicability in determining hydrography elements, histogram analysis allows for obtaining graphical information that can be used to delineate the water line. Histogram analysis will highlight the distribution of pixel intensities in the image, based on which water areas (lower radiometric intensity) and land areas (higher radiometric intensity) can be identified. For illustration, the following data sources will be used:
- A color image with a resolution of 50 cm/pixel containing a hydrographical element;
- The open-source application ImageJ for image processing and analysis;
- The application GlobalMapper Pro v.25 for semi-automatic water line vectorization.

Generating the histogram for the image used as a model aims to identify the minima in the area of interest for easier selection of segmentation thresholds. For this purpose, the colour image was converted into a black and white (grey scale) image using the <Type> - <8 bit> option in the ImageJ application. If the histogram has only two dominant modes, their separation (and implicitly the identification of objects of interest in the image) is done by selecting a grey level called the segmentation threshold. This segmentation threshold

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is chosen by studying the histogram at its local minima. From the initial grey scale image f, a label image g is constructed according to the transformation:

$$g(m,n) = \begin{cases} E0.0 \leq f(m,n) < T \\ E1, T \leq f(m,n) < L \end{cases}$$

The labelled image will be described by two labels: E0 for points, whose grey level is less than the threshold T, and E1 for points whose grey level is greater than the threshold T. Labels E0 and E1can be numerical values (0 and 1 or 0 and 255).

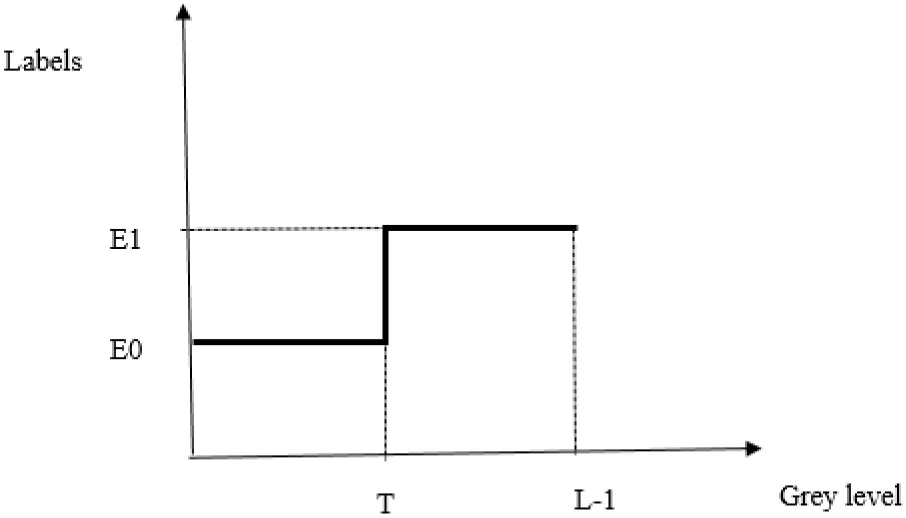

Fig. 2. Punctual binarisation transform

This transformation is a point transformation, meaning the new value at point (m, n) depends only on the previous value at point (m, n), and is called binarisation [1]. The result of the transformation is a binary image, characterized by only two values. In the case of the example image, histogram analysis in the ImageJ application shows that the intensity values of the hydrographical element range between 80 and 110, while the intensities of other elements are higher. The segmentation operation was performed using the <Image> - <Adjust> - <Threshold> option in the ImageJ application.

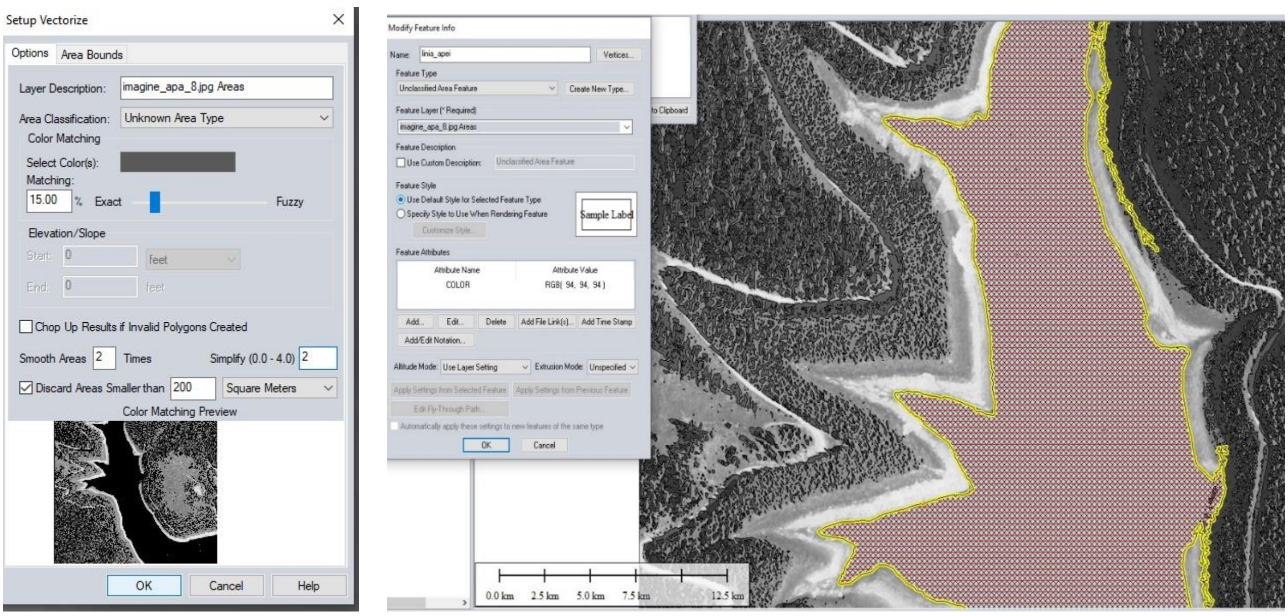

Fig.3. Semi-automated vectorisation of the water line

Semi-automatic vectorisation of the water line is performed by opening the adjusted image in GlobalMapper Pro as follows:

- Select the <Layer> - <Vectorize raster> option;

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- Select the colour representing the water line from the image;
- Set a colour matching threshold of 15%. The matching threshold is visually set using the <Colour Matching Preview> window;
- Remove polygons describing areas smaller than 200 square meters;
- Select the polygon describing the water line and export it in *.shp format.

If a digital terrain model exists for the area, the water line can be exported as a 3D polyline, with the possibility for the vertices describing the resultant polyline to adopt the elevation from the model.

4. Conclusions

Digital photogrammetric images obtained from aerial photography offer the possibility of semi-automatically extracting geometric characteristics necessary for generating profiles used in the probabilistic calculation of flood bands by using simple operations performed with accessible software applications. Considering the vast area of hydrographical basins, using simple data extraction techniques necessary for conducting specialized studies has a positive impact on both costs and the time required to obtain results.

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