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AUTOMATIC CHECKING OF VECTOR-RASTER ALIGNMENT FOR GEOREFERENCED DATA

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Abstract: *This paper proposes a method for automatic checking of the alignment of linear vector data to raster images located in the same coordinate system and projection. The method relies on the analysis of a set of statistical histogram parameters and a set of geometric vicinity parameters. This paper also describes these parameters and provides a practical example that illustrates their development.*

Key words: *vector-raster alignment, image processing*

1. INTRODUCTION

This paper describes a sequence of image processing steps taken to estimate the parameters used in our analysis, as well as the decision criteria for assessing the alignment quality of a linear vector to a raster image. Existing methods are based on algorithms that iterate operations such as the Automated Feature Extraction, followed by vectorization and geometric comparison (Doucette et al., 2007). The method presented in this paper combines radiometric detection with the vicinity with a vector concept applied to objects detected on an image. The proposed criteria for assessing the alignment quality is both radiometric and geometric. The method still needs improvements regarding linear details subject to interruption due to obstructions.

2. THE METHODOLOGY FOR ALIGNMENT CHECKING

The elements of a good overlay include: precise data orthorectification and geocoding, same coordinate and projection system for data and accurate vector data.

Linear details recommended for use are roads because roads rarely change shape and position.

Issues: partial covering of linear details with shadows and obstruction of details by high obstacles due to the perspective projection of the airborne sensors.

Consider an image (Image *I*) and a vector (Vector *V*). The key aspects of the proposed methodology are:

- performing the checking operation inside an image buffer of size δ defined around the vector *V*;
- checking the vector by performing a radiometric evaluation of the statistical parameters computed using raster data from inside the vector buffer, and performing a geometric evaluation of the geometric parameters of the image objects inside the buffer relative to the position of the vector;

Checking is an iterative process that produces images used to determine the parameters for assessment. The decision regarding the quality of the vector-image alignment is taken after analyzing the parameters resulting from the two evaluations.

One must take the following steps to assess the quality of the vector-image alignment:

1) Define the size of δ around the vector *V*.
2) Compute the statistical histogram parameters of the image inside the buffer for each spectral band (R, G, B) (Liu & Mason, 2009): mean *m*, standard deviation σ, obliquity λ, the floor for the main zone of the histogram π^I, the ceiling for the main zone of the histogram π^S, the ratio r^H of the number of pixels with similar radiometry and the total number of pixels inside the interval $[\pi^I, \pi^S]$;
3) Apply certain radiometric processing operators (Russ, 2007) on the image to detect (***, 2011) and vectorize the objects inside the buffer. The utilized operators and the order of their application on the image are: threshold on the interval with limits π^I, π^S; binarization; closure; suppression of small objects; skeletonization; vectorization (***, 2008).
4) Compute the geometric vicinity parameters of the vectors resulting from the vectorization process relative to vector *V*:

- *DMED* – average distance between detected vectors and vector *V*;
- *LTV* – total length of vector *V*;
- *LTO* – total length of detected vectors;
- *LTOM* – total length of detected vectors that are less than the average distance from vector *V*;
- *LTO1* – total length of detected vectors under 1 pixel relative to vector *V*;
- *LTO_LTV = LTO / LTV*. This ratio provides an estimate of how much of the length of vector *V* is covered by detected vectors;
- *LTOM_LTV = LTOM / LTV*;
- *LTO1_LTV = LTO1 / LTV*. This ratio indicates the extent to which vector *V* is covered by detected vectors;
- *LTOM_LTO = LTOM / LTO*;
- *LTO1_LTO = LTO1 / LTO*. This ratio indicates the success rate for detecting vectors that overlay vector *V*.

5) Minimize δ by repeating steps 1 through 4 until the values for δ are exhausted (preferable, δ ≥ 2 pixels);
6) Build variation graphs for the computed parameters as a function of δ;
7) Determine the δ values that fulfill the following conditions:

- $m \approx const$. Keeping constant the brightness mean over an interval of δ values indicates a radiometric compact area.
- σ → min. A minimum value for σ indicates a radiometric homogeneity inside the working area.
- λ → min. A minimum obliquity indicates a symmetry of the probability distribution of brightness levels in the working area. Minimum obliquity indicates the quality of the vectorization of the linear elements along their axes.
- $\pi^I \approx const$, $\pi^S \approx const$ indicate a radiometric compact area.
- *DMED* → min. A minimum *DMED* indicates the detection of image objects close to the position of vector *V*.
- *LTOM_LTV* → max. A large ratio indicates the existence of multiple objects in the working area that could be candidates for affiliation to vector *V*.
- *LTO1_LTV* → max. A value close to 1 is ideal for automatic detection of the vectors;
- *LTOM_LTO* → max. A large ratio indicates that the operation of vector detection completed successfully;
- *LTO1_LTO* → max. A large ratio indicates a high degree of overlay for vector *V* with the detected image objects;

Unfulfillment of most of the optimum conditions in step 7 for a certain value for δ indicates a misalignment of the data. Otherwise the precision of the alignment is given by *DMED*.

3. EXAMPLE

We applied the proposed methodology to a 1000x750m image with a GSD of 50cm and a vector that corresponds to a road approximately 1300m long (Fig. 1).

Interpretation of Results

- the brightness average increases at an approximately constant rate over the entire interval (Fig. 2);
- the standard deviation decreases as the values of δ decrease, reaching the minimum for δ=3 (Fig. 3);
- the obliquity decreases as the values of δ decrease, reaching the minimum for δ=3 (Fig. 4);
- the limits of the predominant domain show two intervals of constancy, separated for the red band at δ=23, for the green band at δ=21, and for the blue band at δ=18 (Fig. 5);
- r^H has a minimum of δ=23 for red, δ=21 for green, and δ=18 for blue, rapidly rising towards a local maximum of δ=4 for green and δ=3 for red and blue (Fig. 6);
- the average distance stays under 3 pixels for values of δ starting with 30 and ending with 3 (Fig. 7);
- the ratio between total length of detected vectors found at a distance under 1 pixel with respect to vector *V* and its total length has a maximum of δ=3 (Fig. 8);
- the success rate of detected vector picks at δ=3 (Fig. 9).

The value of δ that fulfills most conditions is δ=3.

Fig. 1. Image area covered by the vector

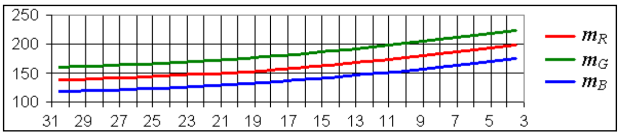

Fig. 2. Values of *m* as a function of δ

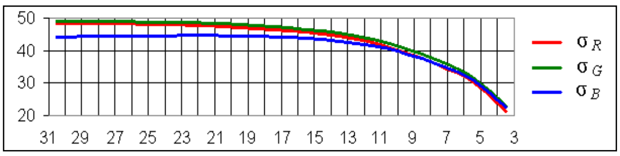

Fig. 3. Values of σ as a function of δ

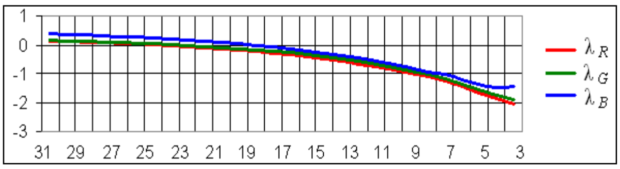

Fig. 4. Values of λ as a function of δ

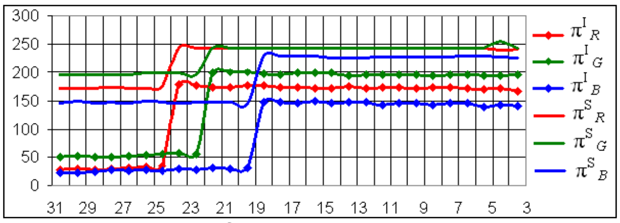

Fig. 5. Values of π^I şi π^S as a function of δ

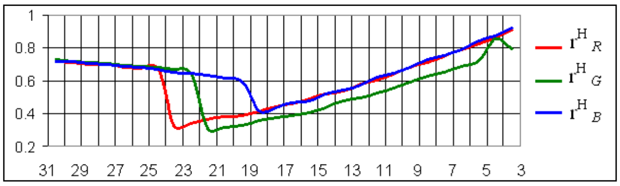

Fig. 6. Values of r^H as a function of δ

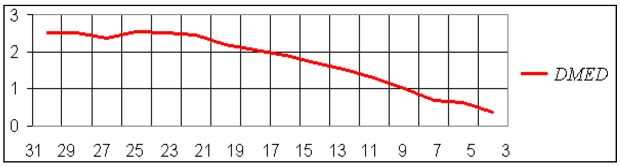

Fig. 7. Values of *DMED* as a function of δ

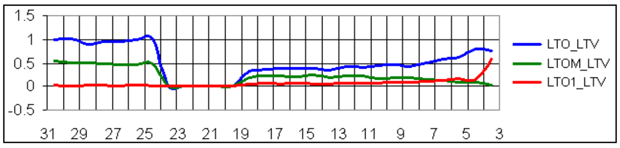

Fig. 8. Ratio of *LTO* and *LTV*

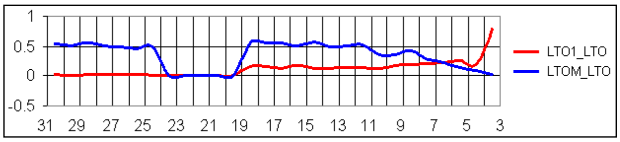

Fig. 9. Ratio of *LTO* and *LTO*

4. CONCLUSIONS

The proposed methodogy for checking the alignment of linear vector elements to raster images is iterative and self-adjusting. It produces decisions based on verifying a set of optimum criteria for the parameters determined during the iterative process. In the case of vectors aligned to raster images, the methodology also indicates the optimum size of the searching buffer used in finding the linear elements on the raster images. For vectors unaligned to raster images, the optimum criteria considered are not fulfilled, and a negative result is reported for checking the alignment.

5. REFERENCES

Doucette, P.; Kovalerchuk, B.; Brigantic, R.; Seedahmed, G. & Graff, B. (2007). A Methodology for Automated Vector-to-Image Registration, *Proceedings of the 36th Applied Imagery Pattern Recognition Workshop*, ISBN 978-0-7695-3066-6, pp. 9-14, IEEE Computer Society, Los Alamitos

Liu, J.G. & Mason, J.P. (2009). *Essential Image Processing and SIG for Remote Sensing*, John Wiley and Sons, Inc., ISBN 9780470510322, New York

Russ, J.C. (2007). *The Image Processing Handbook* (5th edition), CRC Press, ISBN 978-0-8493-7254-4, New York

*** (2008) http://www.aforgenet.com – Aforge.NET Framework, *Accessed on: 2011-03-11*

*** (2011). *Image Segmentation*, Pei-Gee Ho (Ed.), InTech, ISBN 978-953-307-228-9, Rijeka, Croatia