Application of mathematical morphology in digital images for extraction of airport tracks

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Abstract. The products created using remote sensing enables the detection of desired shapes, making possible the update of Cartographic products that can used for a variety of purposes. Techniques of digital image processing are generally used in methodologies of detection and identification of changes. Accordingly, this work aims to present the results of using the Mathematical Morphology (MM) techniques to the extraction of airport tracks from digital images for cartographic products updating.

1. Mathematical Morphology
MM is the study of the shape stem, based on the mathematical theory to describe shapes using sets.

The MM theory is founded on the quantitative description of geometric structures presented in images using algebraic tools, with the aim of extracting relevant information. For this goal, MM is used to analyse the interaction between an image and a chosen structuring element, applying basics operations of erosion and dilation.

2. Airport tracks
We used two infrared images, the first one from Natal airport and the second from Manaus airport, both located in Brazil. The image from Natal was obtained using the Pleiades satellite in August 2014, while the Manaus airport image was captured with the Sentinel satellites in April 2018.

3. Extraction process
The first task performed before the processing was a histogram analysis, and after the images were binarized. However, since the digital levels of the tracks are not the same in both images, the chosen thresholds are different for each one.

Thereafter, the morphological operators were applied. The first one was an area opening, followed by a closing operation and lastly an opening action. The extraction process was the same for both images, and the structuring element and the thresholds were defined in order to obtain the best result for each image.

In order to conclude the analysis of the results in the tracks extraction, it was considered important to compare the results found with the results obtained using other detection techniques. For this purpose, the Sobel and the Prewitt edge detectors were considered, since they are based on the gradient of the image. Therefore, the results when applied Sobel and Prewitt were obtained for the test images and,
from a visual analysis, it was verified that the best result was found with the application of the mathematical morphology method.

**Figure 1.** Result using mathematical morphology (Manaus).

**Figure 2.** Result using mathematical morphology (Natal).

**Figure 3.** Result using Sobel (Manaus).

**Figure 4.** Result using Sobel (Natal).

**Figure 5.** Result using Prewitt (Manaus).

**Figure 6.** Result using Prewitt (Natal).

4. **Statistical Analysis**

A statistical analysis of the quality obtained by the extraction process was also performed, calculating the completeness and the correctness parameters using a software that has been developed by the Mathematical Morphology Research Group of the FCT/UNESP, the Cartomorph.

According to [1], the completeness parameter corresponds to the percentage of pixels in the reference image that were correctly extracted by the methodology used. On the other hand, the correctness indicates the percentage of pixels in the extracted image that coincide with a reference image. For the application of both criteria, a reference images were manually created.

The result of the completeness parameter, presented in the Natal airport analysis, was satisfactory in all the three methods, reaching a value of 99%. However, the correctness was 45% lower for Sobel and Prewitt, whereas for MM the result was 85%.

For the Manaus airport, MM had a completeness of 100% and a correctness of 98%, while for the other two techniques (Sobel and Prewitt) the completeness parameter reached 99% and the correctness 89%.

5. **Conclusion**

The environment constantly changes due to human or natural actions and the updating of these data is often hampered by the country's financial issue. One way to make updating features such as airport tracks more accessible is to use satellite images including those available for free such as Sentinel-2.

As the statistical analysis shows, the result obtained by MM presented better results than the conventional Sobel and Prewitt detectors. Therefore, it demonstrates the great potential of using mathematical morphology for updating of cartographic products.

**References**

[1] Cardim G P, Silva E A and Dias M A 2014 *Transactions on Machine Learning and Artificial Intelligence* **2** 36-51

[2] Leonardi F, Silva E A, Santiago V S and Chaves C D 2013 *Journal of Signal and Information Processing* **4** 308-13