THE USE OF MATHEMATICAL MORPHOLOGY THEORY IN CARTOGRAPHY

Fernando Leonardi
Erivaldo Antônio da Silva
São Paulo State University – Department of Cartography
Rua Roberto Simonsen 305 – Campus Universitário
Presidente Prudente – São Paulo - Brasil
CEP 19060-900
E-mails: fernandoleonardi@gmail.com
erivaldo@fct.unesp.br

Keywords: mathematical morphology, cartographic products updating, Digital Processing Image (PDI)

ABSTRACT

The Cartography has been a fundamental instrument for the projection, landmark and other applications on the terrestrial surface. However, there are deficiencies in the Brazilian cartographic products updating. So, the Sensing Remote Images are contributing to minimize this problem. One of the techniques used is mathematical morphology theory with the aim extracted from the features of interest. The extracted features can be used in conventional processes of cartographic products updating. The main operators used in this paper were mmhdome, mmthreshad, mmareaopen and mmareaclose. For the manipulation images the toolbox developed by SDC Information Systems was used. The tool works with the software Matlab. In a simple place the Matlab software has attended many requirements in the extracted features. The results obtained are positives and show the potential use of mathematical morphology theory in Cartography.

1 INTRODUCTION

In Brazil, there are a lot of areas with a poor cartographic cover. Besides, even in areas with total cartographic cover, the products are most of the times outdate for more two decades. All things considered, the Brazil needs cheaper and faster ways to update cartographic products.

The images of Remote Sensing can be considered as a source of data for studies in several areas such as cartography, urban areas and agricultural environments. Such use can be justified by it is speed, efficiency, periodicity in obtaining data and by its cost.

Remote Sensing is an important agent in the task of cartographic products updating. Another important component of Digital Processing Image (PDI) techniques, which involve digital images manipulation support by a computer.

Among the several PDI tools, the one we chose to develop this research was mathematical Morphology, which has been first explored by Matheron, Serra and their collaborators, in the School of Minas of Paris.

Nowadays Mathematical Morphology (MM) is widely used and researched in universities and research centers worldwide. Therefore it is used with the purpose of updating cartographic products such as charts and maps, and in order to determine feature extraction and treatment. Thus, there is a general consensus that mathematical morphology is an excellent basis to extract the features of interest in the digital images.

2 OBJECTIVES

The general aims of this research are to present the results obtained from the use of Mathematical Morphology in the extraction and treatment of lineal features in images, seeking to aid the processes of cartographic products updating. Also, to verify the potentiality of the tools of mathematical morphology, available in the toolbox of MM couple to the software MATLAB, through the application of routines associated with the task of extracting of features of interest.
3 METHODOLOGY

For the extraction of the features of interest were applied routines of mathematical morphology on satellite images. The software MATLAB 5.3 was used as platform for the toolbox of Mathematical Morphology, which contains the used operators. The operators were applied on the image with the aim of testing their efficiency later in the obtaining results obtained, which can be used, in the updating of cartographic products.

The test image utilities containing the Brazilian Jockey Club in Rio de Janeiro/RJ, Brazil. Such image was taken by the IKONOS satellite through the panchromatic with spatial resolution of 1 meter, polar orbit and sun-synchronous.

In the pre-processing stage, the operators used were: mmhdom, mmthreshad and histeq previously defined. This stage consisted of several tests where, in each one, new parameters were used so that in the end of the process the best possible results were obtained.

On the other hand, in the phase of the extraction, the following operators were used: mmareaclose and mmareaopen.

After extraction of the relevant cartographic features, for the project, that were analyzed, was taken into account if the image presented or no excessive segmentation.

Soon afterwards, the images were put upon to the digital maps. Such a process had the aim of proving the potentiality of the use of the morphologic tools seeking the process of cartographic updating.

The topographic map regarding the Brazilian Jockey Club was converted from the analogical format to the digital through a scanner A4 using the software Adobe Photoshop 7.0. For the georreference, nine control points were used, being these corresponded by the crossing among parallel and meridians of the topographic map.

In the images of the Brazilian Jockey Club the filters conventional Gradient and Sobel were applied so that the visual comparison of the results obtained between the process of morphologic extraction and the conventional methods could be done.

The next step analyzing the results obtained with the application of the new operators and the overlap of the best results obtained in PDI for the images of the Brazilian Jockey Club and their respective digital map. Such analysis has as propose to evidence the potential of the Mathematical Morphology in the extraction of cartographic features seeking the cartographic updating.

4 OBTAINED RESULTS AND ANALYSIS

The tests were accomplished having as base an image IKONOS of the Brazilian Jockey Club (BJC) of the City of Rio de Janeiro - RJ. In the sequence the Illustrations 4.1 and 4.2, show the original image IKONOS (RGB) of the Brazilian Jockey Club and the same image IKONOS in tones of gray (gray scale), the last one was used in the tests.

Illustration 4.1-Image IKONOS of the BJC – RJ
Illustration 4.2-Image in tones of gray
After the conversion of the original image been done in tones of gray (gray scale), it was submitted a denominated stage of pre-processing which has as main objective improving the quality of the present features of interest in the image. For that, the operator \textit{histeq} was applied. This operator through the histogram of the image has the objective of increasing the contrast among the features through an equalization of the tones of gray (gray scale). The image 4.3 presents the result of this operator's application.

![Illustration 4.3-Application of the operator \textit{histeq}](image)

In sequence the operator \textit{mmhdome} was applied (threshold 25), being this also of pre-processing, whose function is to rebuild an image in tones of gray for the subtraction of a integer and positive value, in other words, to remove the picks with larger contrast than the threshold stipulated by the function. The result of this operator's application can be seen by the Illustration 4.4.

![Illustration 4.4-Application of the operator \textit{mmhdome}](image)

After the end of the pre-processing stage, it was applied on the image 4.4, considering as entrance image, the operator \textit{mmthreshad} with thresholds 30 and 200. This operator converts an image from tones of gray to a binary image, using two values, one maximum and the other minimum. Such values are obtained by the histogram of the image. The pixel values that are out of the stipulated interval by the threshold assume the value “0” (black) and the values that are inside of the threshold receive value “1” (white). The image 4.5 represents the result of this operator's application.
Illustration 4.5-Result of the application of the operator *mmthreshad*

The result in the Illustration 4.5 presents the image with only two tones of gray (image binary/black or white). So, it’s possible to apply the other operators with the purpose of eliminating the noises that surround the feature of interest. For that the operator *mmareaclose* was applied (threshold 47800), whose objective of the application was the removal of the largest amount of noises. The result of the application is in the Illustration 4.6.

Illustration 4.6-Result of the application of the operator *mmareaclose*

Starting from the Illustration 4.6 the absence of noises to the surround of the feature of interest can be noticed however, the feature still presents internal “holes”, suitable for the ellipses. For the removal of these interval holes, the operator *mmareaopen* was applied (threshold 295), the aim of this operator is to remove any component with smaller area than the value stipulated in a binary image. The result of application is given by the Illustration 4.7.
The Illustration 4.7 display the feature totally detected. The noises in prominence were eliminated starting from a post-processing in the software Adobe Photoshop 7.0 whose result can be seen by the Illustration 4.8.

To prove that the extracted feature, through the morphologic operators, can serve as base for the updating of cartographic products, the overlap of the result was accomplished containing the extracted feature in the processing with the digital base of the homologous area in the map. The result of overlap is given by the Illustration 4.9.
Observing the obtained result it is possible to notice that there was a great match between the extracted cartographic features of the image (red) and the digital map of the area tests, what proves the usage potentiality of the morphologic tools contained in Toolbox of Mathematical Morphology as alternative technique to the updating of cartographic products.

4.1 Comparison of the results obtained through morphology with conventional methods

This work used the filters of Sobel and Gradient, in the image of the Brazilian Jockey Club applying the conventional method, with the purpose of the visual comparison to be made between the obtained morphologic result and the conventional methods.

Intending of to facilitate the comparison, the results obtained with the application of the filters and through morphology were presented together. In the Illustration 4.10 they are results regarding the BJC image.
In the visual comparison between the obtained results through the morphologic operators and the ones introduced in the Illustration 4.10, it can be noticed that the results conventionally obtained present a larger segmentation around the feature of interest, what makes the updating process difficult and it confirms the potentiality of the mathematical morphology in the extraction of cartographic features.

5 CONCLUSIONS

The obtained results assisted the objectives about the use of the tools of the Mathematical Morphology in the improvement process of the visual quality of the original images and the extraction of the obtained products through remote sensing with updating the cartographic products.

It is worth to stand out that the choice of the operators and appropriate thresholds contributed to the extraction of the features, in which the results indicate that the employed morphologic processings were appropriate.

All of the adopted thresholds based on the analysis of the histograms of the involved images. The appropriate choice of these thresholds is one of the keys so that the obtained results can possibly be the best ones, and with that good results can be obtained without there is the need to apply many operators in the image.

6 ACKNOWLEDGEMENTS

We would like to thank CNPq/PIBIC and FAPESP for the financial support, without which this research project wouldn’t have been accomplished.

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