Ciências Exatas e da Terra: Exploração e Qualificação de Diferentes Tecnologias 2

Raissa Rachel Salustriano da Silva-Matos
Nítalo André Farias Machado
Romário Martins Costa
(Organizadores)

Atena Editora
Ano 2020

Ciências Exatas e da Terra: Exploração e Qualificação de Diferentes Tecnologias 2

Raissa Rachel Salustriano da Silva-Matos
Nítalo André Farias Machado
Romário Martins Costa
(Organizadores)

Atena Editora
Ano 2020

Editora Chefe
Profª Drª Antonella Carvalho de Oliveira
Assistentes Editoriais
Natalia Oliveira
Bruno Oliveira
Flávia Roberta Barão
Bibliotecária
Janaina Ramos
Projeto Gráfico e Diagramação
Natália Sandrini de Azevedo
Camila Alves de Cremo
Luiza Alves Batista
Maria Alice Pinheiro
Imagens da Capa
Shutterstock
Edição de Arte
Luiza Alves Batista
Revisão
Os Autores

Atena Editora
Ano 2020

Atena Editora
Ano 2020

Atena Editora
Ano 2020

Ciências Exatas e da Terra e Engenharias

Atena Editora
Ano 2020

Ciências Exatas e da Terra e Engenharias

Atena Editora
Ano 2020

Ciências Exatas e da Terra e Engenharias

Ciências exatas e da terra: exploração e qualificação de diferentes tecnologias 2

Editora Chefe:	Profª Drª Antonella Carvalho de Oliveira
Bibliotecária:	Janaina Ramos
Diagramação:	Camila Alves de Cremo
Correção:	Vanessa Mottin de Oliveira Batista
Edição de Arte:	Luiza Alves Batista
Revisão:	Os Autores
Organizadores:	Raissa Rachel Salustriano da Silva-Matos Nítalo André Farias Machado Romário Martins Costa

Dados Internacionais de Catalogação na Publicação (CIP)

C569 Ciências exatas e da terra: exploração e qualificação de diferentes tecnologias 2 / Organizadores Raissa Rachel Salustriano da Silva-Matos, Nítalo André Farias Machado, Romário Martins Costa. – Ponta Grossa - PR: Atena, 2020.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-65-5706-485-6
DOI 10.22533/at.ed.856202710

1. Geociências. 2. Ciências exatas. 3. Ciências da terra. I. Silva-Matos, Raissa Rachel Salustriano da (Organizadora). II. Machado, Nítalo André Farias (Organizador). III. Costa, Romário Martins (Organizador). IV. Título.

CDD 550

Elaborado por Bibliotecária Janaina Ramos – CRB-8/9166

Atena Editora
Ponta Grossa – Paraná – Brasil
Telefone: +55 (42) 3323-5493
www.atenaeditora.com.br
contato@atenaeditora.com.br

Atena Editora
Ano 2020

APRESENTAÇÃO

A tecnologia encontra-se cada vez mais presente em nossas vidas, mudando completamente a nossa interação e percepção do mundo. No universo científico não é diferente, sobretudo por conta de o progresso tecnológico estar contribuindo constantemente no desenvolvimento de métodos de aquisição e análise de dados.

Neste livro são apresentados vários trabalhos com métodos modernos de exploração de dados usando diferentes tecnologias nas Ciências Exatas e da Terra, alguns com resultados práticos, outros com métodos tecnológicos que auxiliam na tomada de decisão na ótica sustentável e outros com métodos de desenvolvimento para o ensino de tecnologias.

A obra "Ciências Exatas e da Terra: Exploração e Qualificação de Diferentes Tecnologias 2" aborda os mais diversos assuntos sobre a aplicação de métodos e ferramentas nas diversas áreas das engenharias e ciências sociais aplicadas a fim de divulgar métodos modernos de tecnologias aplicáveis, métodos sofisticados de análises de dados e melhorar a relação ensino aprendizado, sendo por meio de levantamentos teórico-práticos de dados referentes aos cursos ou através de propostas de melhoria nestas relações. Portanto, a obra possui um relevante conhecimento para profissionais que buscam estar atualizados e alinhados com as novas tecnologias.

Raissa Rachel Salustriano da Silva-Matos

Nítalo André Farias Machado

Romário Martins Costa

SUMÁRIO

CAPÍTULO 1

RECONSTRUCTION OF PARTIALLY DETECTED DARK SLOPE STREAKS FROM AUTOMATIC EXTRACTION ALGORITHM USING INPAINTING TECHNIQUE

Data de aceite: 01/10/2020
Data de submissão: 04/07/2020

Erivaldo Antônio da Silva
UNESP, Departamento de Cartografia
Presidente Prudente - São Paulo
https://orcid.org/0000-0002-7069-0479

Breno Strogueia Maia da Cruz
UNESP, Departamento de Cartografia
Presidente Prudente - São Paulo
https://orcid.org/0000-0001-7686-3433

Ana Luisa Chaves Figueira
UNESP, Departamento de Matemática e Computação
Presidente Prudente - São Paulo
https://orcid.org/0000-0002-7894-3020

Samara Calçado Azevedo
UNIFEI, Instituto de Recursos Naturais
Itajubá – Minas Gerais
https://orcid.org/0000-0001-6237-3070

Pedro Pina
CERENA/IST – Universidade de Lisboa, Departamento de Engenharia de Minas
Lisboa - Portugal
https://orcid.org/0000-0002-3199-7961

ABSTRACT: This paper proposes the implementation of an algorithm that automatically detects features of interest on Martian surface, also known as Dark Slope Streaks (DSS). The major difficulty faced by this type of algorithm is the presence of false positives caused by shadows, depressions, or fading of DSS, after a period. To avoid these problems, techniques such as thresholding, image segmentation, binarization, and customized filtering routines were used to develop an extraction algorithm. Unfortunately, the extraction algorithm obtains partially detected features, culminating in loss of quality. Thus, in order to remove occlusions and restore lost features, we have used an inpainting technique proposed in the literature. Experimental analysis was performed using a reference image manually created which was compared with both, the image obtained from the extraction process and the resulting image from inpainting algorithm. This process was repeated for three areas of interest. Comparing the mean of structural similarity (SSIM) pre-reconstruction and post-reconstruction, the inpainting algorithm showed an improvement of 15.85% in quality. Therefore, both algorithms clearly contribute greatly to the increasing quality of extraction of DSS in the area of cartography.
KEYWORDS: Remote Sensing, Dark Slope Streak, Cartography, Digital Image Processing, Inpainting.

RECONSTRUÇÃO DE DARK SLOPE STREAKS PARCIALMENTE DETECTADOS A PARTIR DE EXTRAÇÃO AUTOMÁTICA USANDO TÉCNICA DE INPANTING

RESUMO: Este artigo propõe a implementação de um algoritmo que detecta automaticamente características de interesse na superfície marciana, também conhecidas como Dark Slope Streaks (DSS). A principal dificuldade enfrentada

por esse tipo de algoritmo é a presença de falsos positivos causados por sombras, depressões ou desbotamento do DSS, após um período. Para evitar esses problemas, técnicas como limiar, segmentação de imagem, binarização e rotinas de filtragem personalizadas foram usadas para desenvolver um algoritmo de extração. Como resultado inicial, o algoritmo de extração obtém recursos parcialmente detectados, culminando em perda de qualidade. Assim, para remover oclusões e restaurar características perdidas, foi utilizada uma técnica de inpanting proposta na literatura. A análise experimental foi realizada utilizando uma imagem de referência criada manualmente e comparada com ambas, a imagem obtida no processo de extração e a imagem resultante do algoritmo de inpanting. Este processo foi repetido para três áreas teste. Comparando a média de similaridade estrutural (SSIM) pré-reconstrução e pós-reconstrução, o algoritmo de inpanting mostrou uma melhoria de 15,85% na qualidade. Portanto, ambos os algoritmos claramente contribuem bastante para o aumento da qualidade da extração do DSS na área de cartografia.
PALAVRAS-CHAVE: Sensoriamento Remoto, Dark Slope Streak, Cartografia, Processamento Digital de Imagens, Inpainting.

1 I INTRODUCTION

The process of extracting features of interest from digital images has been widely used in the area of Cartography. Due to its importance, several studies are dedicated to processing such images in order to extract features/objects more easily, and consequently, more accurate image feature analysis is reached. One of the biggest issues in object detection is the natural changes at the same area through time. Martian surface isn't an exception, since they alter the formation of its surface, resulting in residues overlaying onto the objects of interest or just destroying the objects itself. That way the surface is captured in different periods and has to be analyzed with different approaches. The analysis occurs by applying a series of methods to detect unconventional features, such as volcanoes, landslides, storms, fires, and craters, among others. One type of feature in the Martian surface is the Dark Slope Streak (DSS), whose nature remains unknown. Because of this unknown nature, several works are made focusing on the process which forms DSSs, their composition. This study can lead to a better understanding of the planet water cycle, climatic changes and other natural phenomena.

Therefore, this paper proposes an algorithm to automatically detect DSS based on the algorithm first mentioned in (Carvalho, 2016).

Unfortunately, some of the results obtained in this algorithm have partially detected features, culminating in loss of quality from the extraction process.

To solve this problem, inpainting techniques can be applied based on the inpainting concept that promotes an image restoration and removal of occlusions. It operates by gathering information around the damaged area and making a subtle junction of this information with the area of interest.

In this sense, the purpose of this paper is to detect automatically DSS and apply the inpainting technique proposed by (Deng et al. 2015), aiming to improve the quality of the DSS extraction results.

2 | THEORETICAL FOUNDATION

a. Dark Slope Streaks

One of the most simplistic ways to describe a Slope Streaks shape is found in (Carvalho, 2016) and (Sullivan et al. 2001): “Dark Slope Streaks are dark, fan-shaped trails that extend down steep slopes on the surface of Mars”. In addition, studies from (Carvalho, 2016) and (Sullivan et al. 2001) describe its composition being “made up of dust and other substances not yet identified”. However, what generates these Dark Slopes Streaks still undiscovered

One of the first discoveries while studying Dark Slope Steaks was that these features become lighter and fade over time, often making detection difficult (Vala et al. 2013).

Figure 1 shows Slope Streaks from the same region at two different times, the left in February 2000 and the right in February 2004. Both captured by the MOC camera.

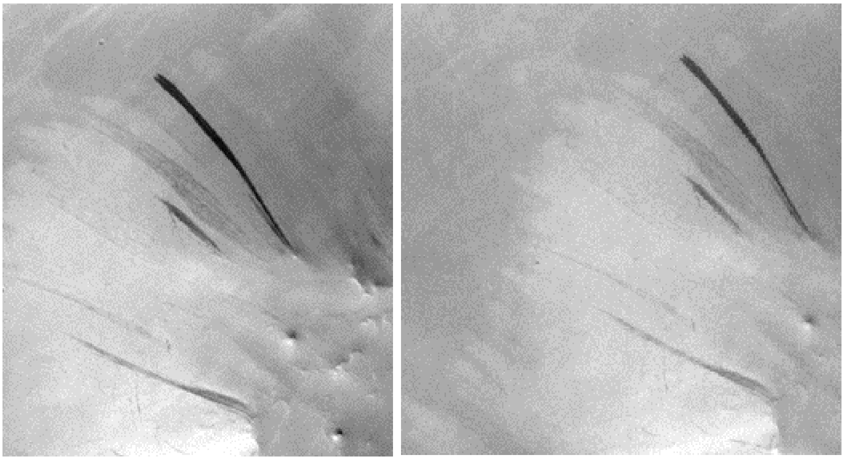

Figure 1: Image captured by MOC camera.

One of the main issues that leads into more time consuming and sometimes less productive works are the fact that only specialized teams are allowed to detect and study the phenomena in the images. At the same time, the only real issue in this approach are the method used to detect Slope Streaks, nowadays this process is made manually.

Therefore, the development of a method that automates DSS detection would increase the effectiveness of the study, collaborating with the understanding of its nature and discoveries about the subject. Focused on contributing to improve the effectiveness of DSS identification that this work was carried out.

b. Thresholding

Thresholding is a segmentation process applied in digital image processing in order to find a central value used in further binarization process. This process leading to the segregation of the image into two layers of the images: the first containing object of interest and the remaining other the rest of the scene (including the background). As mentioned before thresholding is commonly used as an input parameter for other image processing algorithms, and such as the "Otsu Method", which can be used to determine the input parameter automatically, that process will be described further on. The process to achieve the central value for the algorithm are is made from several comparisons between the tonalities of the pixels present in each segment of the image, always seeking to define the most appropriate threshold. Therefore, so that the object and / or target of interest is better detected after the thresholding process.

Among these various calculations, the original image will always be preserved, thus allowing this process to be executed as many times as necessary within the algorithm routine.

c. Otsu Method

The Otsu method is an image thresholding algorithm designed to separate an object and the background, and (Kenneth et al. 2015) in its final step transforms the image into a binary one, where the "1" of the image (blank part) is the objects and the "0" of the image (part in black) is the background of the image.

The segmentation of images is one of the most basic problems of image processing and computer vision. To do such segmentation, the algorithm in its routine divides the original image into several subareas and classifies them into two classes, the first with the pixel intensities lighter and the second with the darker intensities. For each division, pixels weight are estimated searching to a unique value that maximizes the sum of the means in these inter-classes. By the end of the process, we have an image ready to be segmented in values of "0" and "1" with the best value approach possible as parameters to the binarization. In other words, Otsu Method will find a threshold that minimizes the weighted within-class variance.

Otsu method is one of the most used segmentation image methods due to its simplicity and stability in the process of calculating a global threshold that is suitable for the most kind of images, based only on the distribution of gray levels arranged in a histogram. However, due to its simplicity, the result is heavily affected by blur and noises. Therefore, because the remote image captured by satellites is likely to have those, the final result may be worse than expected.

d. Inpainting

Inpainting is a known concept that aims at rebuilding damaged or removed portions of an image, in a way that makes it more readable.

In a common image, the pixels contain both, real data information and noise. Considering that there is no significant information in the region where the inpainting action will be performed, the information to be considered will be only the one that is in the regions around the selected region. It is important to observe that a correct solution to detect missing data in an image is detecting regions where this occurs. This would enable a reconstruction algorithm that concentrates only in damage areas, leading to reduce the reconstruction errors [3].

There are several ways to approach the concept and, according to [2], these approaches can be divided into three main groups. The first handles the restoration of images and videos; the second is related to texture synthesis, in which the restoration occurs through the insertion of textures by the user, and finally, the third is related to the occlusions removal. This paper is included in the first and second group.

e. (Deng et al. 2015) Inpainting Algorithm

The algorithm proposed by Liang-Jian Deng Ting-Zhu Huang, Xi-Zhao is not based on partial differential equations (EDPs). It fills regions of interest by copying and pasting the portions of the source regions, so that the texture of the image remains the same. The type of technique exploited by this algorithm is called exemplar-based.

Originally, exemplar-based algorithms are based on two attributes: a confidence term and a data term. The data term propagates the target region geometrically, and the term of confidence describes the dependence of the area of the patch to be copied and pasted concerning the neighboring pixels of the source region, that is, the texture propagation of the original image. If there are more pixels of the source region around a pixel p, the confidence term of p will get a higher value.

Equations (1) and (2) define the priority of a patch, so we select the one with the highest priority, and fill the target region with the patch from the source region that is most similar to it,

$$\begin{cases} C(p) = 0, \forall p \in \Omega \\ C(p) = 1, \forall p \in \omega \end{cases} \quad (1)$$

$$D(p) = -0.1, \forall p \in \Omega \cup \omega \ (2)$$

Where C(p) and D(p) is the confidence term and data term of a pixel, respectively, Ω is the area of interest and ω is the region that does not belong to the area of interest.

The similarity between two patches is measured by the following equation,

$$\gamma_p = {}^{argmin}_{\gamma_q \in \theta} d(\gamma_p, \gamma_q) \ (3)$$

Each pixel p' is filled with the corresponding pixel in y_q, by using equation (4),

$$p' \in \gamma_p \cap \Omega \ (4)$$

Then, the confidence term is updated to,

$$C(q) = C(p), \forall q \in \gamma_p \cap \Omega \ (5)$$

All of these processes are repeated iteratively until the target region is completely filled. What differentiates the technique proposed by [2] from the common exemplar-based algorithms is a new definition of the priority criteria and the similarity equation used. The new priority definition is described in equation (6),

$$P(p) = \begin{cases} D(p), for\ the\ first\ phase \\ C(p), for\ the\ second\ phase \end{cases} \ (6)$$

The first phase concentrates on the geometric propagation of the target region, and the second, the propagation of the texture. The algorithm automatically estimates the number of iterations required for the execution of the first phase.

As for the similarity equation, it was changed to equation (7),

$$\gamma_p = {}^{argmin}_{\gamma_q \in \gamma'_q} d(\gamma_q, \gamma_p) \ (7)$$

where y_p and y_q are patches being compared, y'_q is the largest patch with its center being y_q's center and $d(y_q, y_p)$ is the sum of the quadratic differences of the pixels that already filled the two patches.

3 I METHODOLOGY

a. Test images

The images used in this work correspond to those captured by the MOC satellite (Mars Orbiter Camera). It is worth mentioning that, in its initial phase, the images used were manually selected and cropped to the interesting areas. After the images have been cropped, they had an average size between 150 x 200 pixels at

300 x 500 pixels. The software MATLAB and the Image Processing toolbox was used for the algorithm itself. The test images selected for this paper are illustrated below.

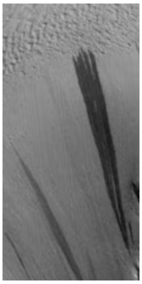

Figure 2: Input image of size 116x199 pixels.

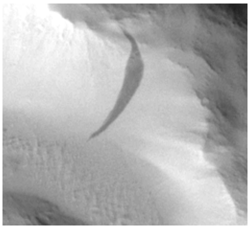

Figure 3: Input image of size 235x212 pixels.

Figure 4: Input image of size 372x590 pixels.

b. Methodology

The methodology of this paper is dived in three parts, the first being the development of an algorithm of detection of DSS in Martian images; the second is related to the reconstruction of the results obtained by the extraction algorithm, and the final one, shows how the results will be displayed and analyzed.

c. DSS Detection Algorithm

To achieve better results, the algorithm was divided into stages. The first step was the pre-processing of the image, which consisted in analyzing the image by its dimensions, and adapt sizes of SE that will be used in the algorithm in later on;

when needed, it was calculated the maximum and minimum value of pixels in the entire image to manually adjust tresholding parameters. To adjust SE size in various functions, the average size of the features was used.

After the previous stage the image pre-processed undergoes to a stretching process in order to highlight the Slope Streaks. This stage is key for a good and smooth detection in future stages, after stretching, a top-hat filter is applied.

After the stretching and filter, the average between pixels values was calculated to improve the definition of the threshold and begin the manual thresholding of objects in the next stages. Methods implemented in the toolbox were used to perform these calculations, following the similar steps to the Otsu method.

For the last stage of the methodology, the process of filtering the image by the *bwareaopen*, *imerode* and *bwmorph* operators is carried out using as “clean” and “spur” as parameters. Such methods remove detected objects that are smaller than a certain number of pixels. This number of pixels is found based on the resolution of the input image and objects measures previously.

The result obtained of the detection is overlaying onto the original image in order to confirm that there was no change in the geographic position of the objects or any deformations were caused in the objects detected.

The algorithm was developed based only on predetermined images. The next steps of this work were perform to reach better detection in whole images captured by the satellite, whose size, in pixels, can have resolutions greater than 1000x3000 pixels.

In order to apply to the methodology in images of this size, it will be necessary first, to adapt the parameters: resizing structuring elements, reshaping in some specific cases, and remove what will be considered noise in the image (false detections). In future phases will also be evaluated if it will be necessary to divide the image into smaller sections for the analysis, as recommended by the Otsu method.

d. Development and analysis Inpainting Algorithm

This part of the methodology consists in the elaboration of the algorithm referring to the technique of (Deng et al. 2015), and in the statistical analysis of the obtained results.

In (Feier et al. 2012), (Meur et al. 2014), (Dang et al. 2013) the lack of quantitative metrics to evaluate the results of an inpainting process is addressed. The reason why this happens is related to the lack of reference image, and also because the content of the area to be rebuilt is unknown. Therefore, in most of cases, visual evaluation is used, where it is verified if the result is appropriate. However, the task to analyze results visually is complex and unpredictable due to human factors that are difficult to control. Thus, an alternative is to use known quality metrics in the area of digital image processing, among them the most used ones are: mean square error (MSE), peak signal-to-noise ratio (PSNR) and structural similarity (SSIM).

The MSE is an estimator, its value is always positive and the results close to zero are better.

The PSNR is the relation between the maximum signal value and the maximum noise value that affects the fidelity of image representation. To calculate it, the MSE is needed. The latter, SSIM, is an index that predicts the quality of images and videos when measuring the structural similarity between two images. SSIM was created as an enhancement of MSE and PSNR measures.

The main difference between SSIM and its predecessors is that SSIM is a method based on visual perception. (Peter et al. 2010), (Maged et al. 2016), (Furht, 2005), and (Schorghofer et al. 2011) reiterate that SSIM is more efficient when compared to MSE and PSNR methods. This is due to the latter not detecting distortions perceptible by the human visual system. The reason why this happens, as mentioned by both papers that way is that they only consider the individual state of each pixel and not its structural information, contrary to how SSIM operates.

Also in (Furht, 2005), (Zhang et al. 2007), (Zhou, 2016) and (Guilhon, 2013) it is argued that MSE and PSNR are not suitable for binary images. In this case, the MSE represents the number of differences between two images, and a large number of different pixels does not always result in a large structural difference, because binary images do not have many texture details and their pixel distribution is simpler.

e. Obtaining and analyzing the results

First, the DSS detection algorithm is applied to the test images, and then the partial features are obtained. After that, the manual construction of a reference image is done, based on the original unprocessed image.

The SSIM metric is used to evaluate the quality of the results obtained. The metrics were applied in the input images and in the inpainted results. When compared with the SSIM of the input image, the results obtained after the application of the technique demonstrated the improvement of the quality of the methodology.

Results obtained from automatic detection are present in double images, the first image being the original image, used as input of the detection algorithm. The second is the result of the detection algorithm in which the detection of DSS is outlined by red edges around it; the original image is overlaid by this detection.

Figure 5: Original image satellite MOC 04/2006.

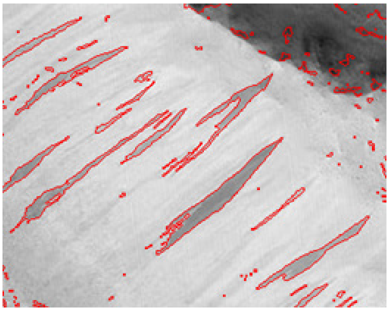

Figure 6: Detection result from Figure 5.

After processing over 150 images and analyzing, we can affirm that the algorithm fulfills its role to detect DSS and has high performance in different situations. For example, when areas where the DSS are very detached from his neighborhood, as shown in Figure 5 and the detection in Figure 6, another one is when DSS is faded, according to Figure 7 and the detection in Figure 8.

However, despite the results of feature detections being accurate, it is noticeable that some targets that are not DSS, such as shadows, terrain relief, and depressions were detected. Such targets can be considered as false positives and were detected incorrectly due to the inappropriate thresholding parameters selection and binarization.

Another factor that directly affects the detection of false positives is the spatial resolution of the image used as input image. This factor has not yet been incorporated into the algorithm and will be further addressed in the future. High spatial resolution images having higher number of pixels than those of lower spatial resolution.

The spatial resolution of an image is very important to consider in this algorithm, it affects the dimensions of the structuring elements and to the selection of parameters used in functions such as morphological opening and closing.

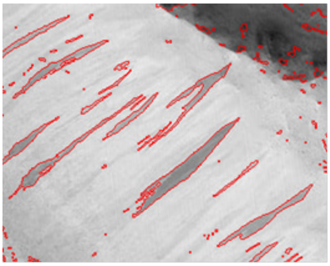

Figure 7: Original image satellite MOC 02/2012.

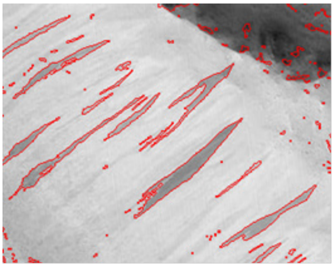

Figure 8: Detection result from Figure 7.

Figure 9a shows the input image 1, Figure 9b, the detected DSS reached from automatic detection, Figure 9c, the reference image, and Figure 9d, the result obtained from the implemented inpainting algorithm.

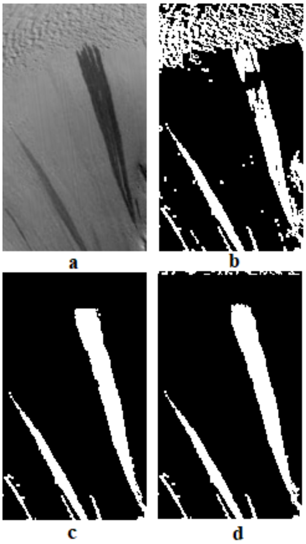

Figure 9: Results obtained for test image 1.

The result showed in Figure 9a, 9b, 9c, and 9d, regarding to the reconstruction of input image 1, have reached SSIM of 64.18% from input image and a SSIM of 94.31% from resulting image

Figure 10a shows the input image 2, Figure 10b, the detected DSS reached from automatic detection, Figure 10c, the reference image, and Figure 10d, the result obtained with the implementation of the inpainting algorithm.

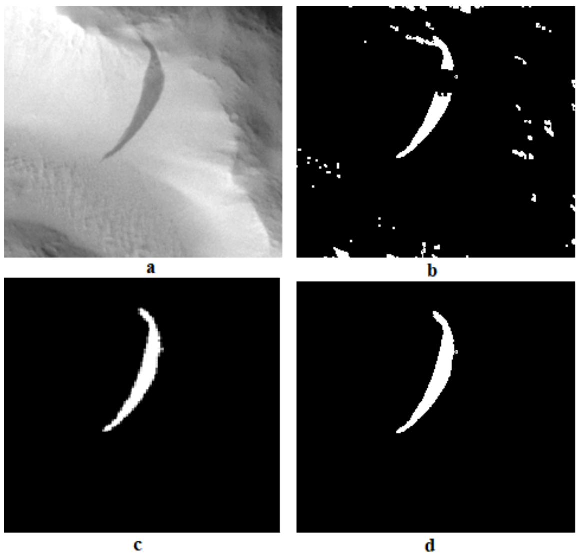

Figure 10: Results obtained for test image 2.

The result obtained on image 2 was a SSIM with 88.15% and in the resulting image was 97.99%.

Figure 11a shows the input image 2, Figure 11b, the detected DSS reached from automatic detection, Figure 11c, the reference image, and Figure 11d, the result obtained with the implementation of the inpainting algorithm.

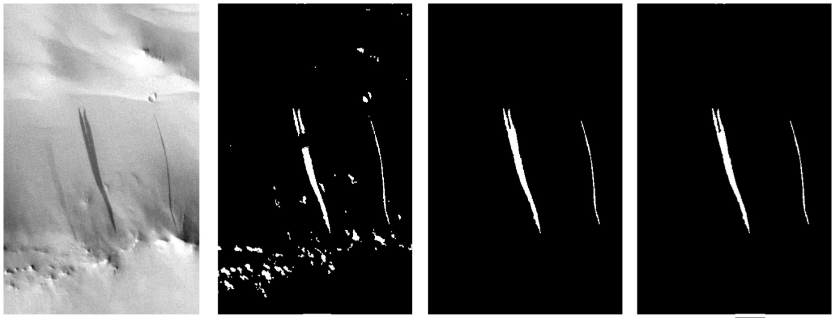

Figure 11: Results obtained for test image 3.

Figure 11a, 11b, 11c, and 11d, shows the last input image 3, which reached a SSIM of 92.18% from input image and a SSIM up to 99.76% after inpainting applied in the resulting image

All the obtained results indicate that the inpainting technique improved the quality of DSS extraction, by performing the reconstruction of partially detected features.

The processing time of the algorithm, vary according to the number of areas of interest, that is, the smaller the number of areas of interest, the lower is the processing time. In addition, the results of the quality of the extraction process of input images showed an average of SSIM = 91.19%, while after the application of the technique the average has increased to 97.78%. Which demonstrated a significant improvement.

In order to facilitate the visualization of the results obtained with the application of the technique of inpainting, Table 1 presents all the results obtained.

Test Image	SSIM of DSS extraction (%)	SSIM after inpainting (%)
1	64.18	94.31
2	88.15	97.99
3	92.18	99.76
Mean	81.503	97.353

Table 1: SSIM comparison between original images and results of the inpainting technique

4 | CONCLUSIONS

From the automatic detection results analysis, it is noticed that DSS were efficiently detected. The methodology used for the detection process can be used for any feature containing DSS, as long as the appropriate threshold is applied to each image, as described in the Methodology.

There are still improvements to be implemented for the refinement of detection, such as the incorporation of spatial resolution treatment. Investigations related to thresholds for object extraction will be addressed in future stages.

Observing the final analysis of the results obtained with the technique proposed by Liang-Jian Deng Ting-Zhu Huang, Xi-Zhao [1] in the input images, we clearly see that the results were highly satisfactory.

The good results obtained regarding to the improvement of the quality of extraction process of partially detected cartographic features can be used in the area of cartography.

ACKNOWLEDGEMENTS

The authors thank the Foundation for Research Support of the State of São Paulo - FAPESP (Process nº 2017/16107-0, Processes nº 2017 / 13029-8 and 2018 / 21965-8) and the National Council of Scientific Research-CNPq.

REFERENCES

Beena, M.V., Samuel, N., Kurian, R. (2013). Occlusion Removal and Various Techniques for Removing Occlusions. *International Journal of Emerging Technology and Advanced Engineering*.

Carvalho, F. (2016). Detecção automática e análise temporal de slope streaks na superfície de Marte.

Dang, T. T., Beghdadi, A., Larabi, M. C. (2013). Inpainted image quality assessment. *European Workshop on Visual Information Processing (EUVIP)*.

Deng, L-J., Huang, T-Z., Zhao, X-L. (2015). Exemplar-Based Image Inpainting Using a Modified Priority Definition. *PLoS ONE*.

Kokaram, A. C. (1995). Detection of Missing Data in Image Sequences. *IEEE Transactions on Image Processing*.

Feier, O., Ioana, A. (2012). Digital Inpainting for Artwork Restoration: Algorithms and Evaluation, 97f.

Fundamentos de Computação Gráfica - INF2608 - 2013.1.

Furht, B. et al. (2005). Multimedia Encryption and Watermarking. *Springer US*.

Kenneth, S., Brian, F., John, L., Michael, D. Spatial Resolution in Digital Imaging.

Maged, W., Rasha, E. (2016). Quality Assessment of Visual Cryptography Images. *Australian Journal of Basic and Applied Scienc*es.

Meur, O. L., Guillemot, C. (2014). Image Inpainting: Overview and Recent Advances. *IEEE Signal Processing Magazine*.

Peter, N., Hisakazu, K., Masahiro, Y., Hidenori, W., Shogo, M. (2010). SSIM image quality metric for denoised images. *International Conference on Visualization, Imaging and Simulation – Proceedings*.

Schorghofer, N., King, C. M. (2011). Sporadic formation of Slope Streaks on Mars. *Icarus*.

Soille, P. Morphological Image Analysis. (2004). *Berlin: Springer-Verlag*.

Sullivan, R., Thomas, P., Veverka, J., Malin, M., Edgett, K. (2001). Mass movement slope streaks imaged by the Mars Orbiter Camera. *Journal of Geophysical Research*.

Vala, M. H. J., Baxi, A. (2013). A Review on Otsu Image Segmentation Algorithm. *International Journal of Advanced Research in Computer Engineering & Technology*.

Zhang, C., Qiu Z. (2007). Simple quality assessment for binary images. *Journal of Electronics (China)*.

Zhou, W. (2016). Objective Image Quality Assessment: Facing the Real-World Challenges. *Electronic Imaging*.

ÍNDICE REMISSIVO

A

B

C

D

L

M

N

O

P

Ciências Exatas e da Terra: Exploração e Qualificação de Diferentes Tecnologias 2

www.atenaeditora.com.br
contato@atenaeditora.com.br
@atenaeditora
www.facebook.com/atenaeditora.com.br

Atena Editora
Ano 2020

Ciências Exatas e da Terra: Exploração e Qualificação de Diferentes Tecnologias 2

www.atenaeditora.com.br
contato@atenaeditora.com.br
@atenaeditora
www.facebook.com/atenaeditora.com.br

Atena Editora
Ano 2020