Evaluation of the Image Quality Index in Mosaics

Pedro Henrique Soares de Almeida[1], Joel Zubek da Rosa[1], Selma Regina Aranha Ribeiro[2], Luciano José Senger[1]

[1]Departamento de Informática
Universidade Estadual de Ponta Grossa (UEPG) – Ponta Grossa, PR – Brazil

[2]Departamento de Geografia
Universidade Estadual de Ponta Grossa (UEPG) – Ponta Grossa, PR – Brazil

{pedro.almeida1191,joel14zubek,selmar.aranha,ljsenger}@gmail.com

Abstract. *The focus of this study is the evaluation of the Image Quality Index (IQI) in mosaics generated from aerial images collected by a Remotely Piloted Aircraft (RPA). The software packages used to generate the mosaics were PhotoModeler, PhotoScan and Pix4Dmapper. The mosaic generated by the software PhotoScan was superior to the others visually, but inferior to the software PhotoModeler in relation to the average of the quality indexes calculated. The average values of the IQIs obtained for the mosaics generated by the software packages PhotoModeler, PhotoScan and Pix4Dmapper were 0.98118, 0.94814 and 0.93256, respectively. An analysis of variance was performed but did not present a significant difference.*

1. Introduction

One of the reasons for the proliferation of Remotely Piloted Aircrafts (RPAs) is its application in agriculture. Obtaining frequent aerial images of their farms allow the farmers to make informed decisions related to various farm practices. In a typical application, a RPA equipped with cameras is flown over the field collecting georeferenced images that are used to build a mosaic and assist the agricultural decision-making process [Li and Isler 2016].

Image mosaicing is the alignment of multiple overlapping images into a large composition which represents a part of a 3D scene [Capel 2004]. The research community demonstrates real interest in this area for both its scientific significance and potential derivatives in real world applications [Ghosh and Kaabouch 2016].

Several companies also show interest and focus their efforts on this area through their commercial software packages, such as *PhotoModeler*, *PhotoScan* and *Pix4Dmapper*. The latter two are the most popular paid aerial imagery and photogrammetry processing software packages, with relatively simple user interfaces and comprehensible manuals, as well as an established track record of use for professional aerial mapping applications [Kakaes et al. 2015].

Mosaicing involves various steps of image processing: registration, reprojection, stitching, and blending. During these steps, distortions or errors propagated through geometric and photometric misalignments may occur, which often result in undesirable object discontinuities and stitching visibility near the boundary between two images, impairing the final quality of the mosaic.

Although the visual verification of image quality is widely used in this area, a quantitative form of quality evaluation can be useful to the observer in situations of difficult visual distinction in relation to image quality.

Image Quality Index (IQI) is applicable to various image processing systems and provides a meaningful comparison across different types of image distortions. This quality index models any distortion as a combination of three different factors: loss of correlation, luminance distortion, and contrast distortion [Wang and Bovik 2002].

Two images are required to perform the calculation of the IQI: the original and the test (an image that may have suffered some type of distortion). The result is a numerical value ranging from [-1, 1] and indicates the quality of the test image relative to the original image. The closer to 1 (one), the higher the quality.

In this context, the objective of this study was to evaluate the Image Quality Index in mosaics generated by the aforementioned software packages.

2. Material and Methods

The images used in this work to generate the mosaics were provided by [Perin et al. 2016]. They were collected in an experimental area of the Campos Gerais region, at Fazenda Santa Cruz, located in the city of Ponta Grossa – PR. The equipment used was a RPA *eBee* [1] (Figure 1), manufactured by *senseFly*. The flight was conducted at an altitude of 120 meters on 11 August 2016, between 12h and 14h. The aerial platform was equipped with a *Sony Cyber-shot RGB* camera with 18.2 megapixels, allowing images with 3.4 cm/pixel resolution.

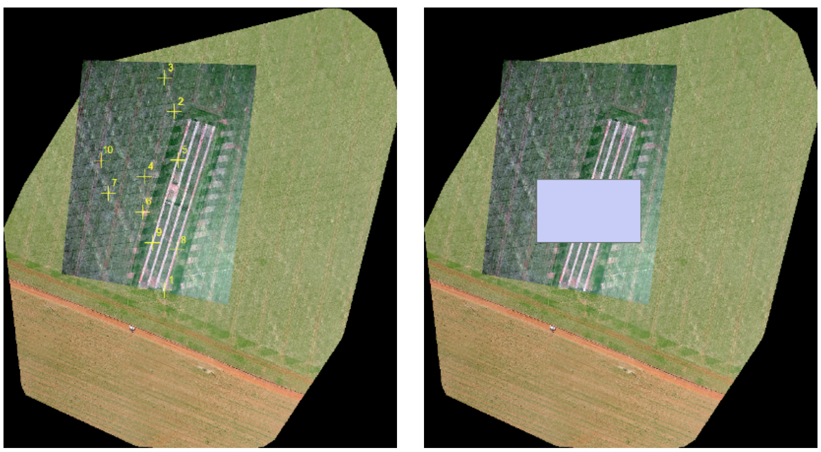
Figure 1. RPA *eBee* - *senseFly*

The software packages used to generate the mosaics were *PhotoModeler* [2] (version 2017.0.2), *PhotoScan* [3] (version 1.3.2) and *Pix4Dmapper* [4] (version 3.2.23). In all

[1] https://www.sensefly.com/drones/ebee.html
[2] http://www.photomodeler.com/products/UAS/default.html
[3] http://www.agisoft.com/
[4] https://pix4d.com/product/pix4dmapper-pro/

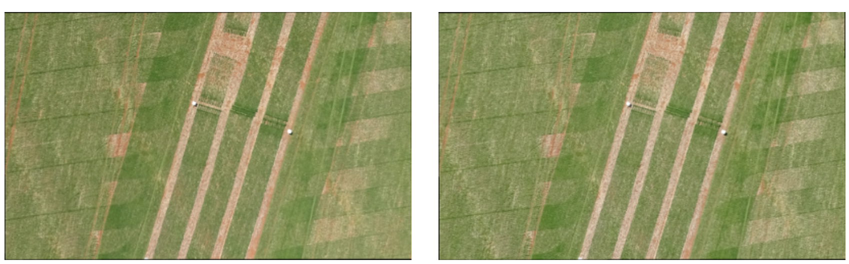
the software packages the default settings were used. Other tools such as ArcMap [5] (version 10.3.0) and MATLAB R2017a [6] (version 9.2.0) were also used to georeference the images and perform the IQI calculation, respectively.

The first mosaic was generated by the software *Pix4Dmapper*. Once generated, the ArcMap tool was used to georeference the original images on it, as shown in Figure 2(a). In the ArcMap tool 25 (twenty five) control points per image were randomly collected, but only 10 (ten) with the lowest Root Mean Square Error (RMSE) were kept. In addition, a second-order polynomial transformation was used to soften the generated RMSE. Then, an area was selected within the georeferenced image that visually presented the least georeferencing RMSE in relation to the mosaic. In this area, a cutout was made in both the original georeferenced image and the mosaic (Figure 2(b)).



(a) Georeferencing (b) Cutouts

Figure 2. Example of georeferencing and cutouts made



(a) Cutout of original image (b) Cutout of mosaic

Figure 3. Cutouts made in the original georeferenced image and in the mosaic

When a mosaic is generated, it is common to occur geometric transformations in the images that compose it, for example, to correct possible radial distortions in the original images and to maintain an uniform appearance. Thus, the georeferencing of

[5]http://desktop.arcgis.com/en/arcmap/
[6]https://www.mathworks.com/products/matlab.html

the original images (which were not geometrically transformed) in the generated mosaic usually accumulates a RMSE, which, in the case of this study, presented higher in its edges. For this reason, a central cutout was chosen in the images of the mosaic, where the RMSE was smaller (insignificant) and the original aspect was better kept, avoiding misconceptions in the IQI calculation.

The obtained cutouts (Figure 3) were used to perform the IQI calculation through the MATLAB tool. The source code [7] was implemented and made available by [Wang and Bovik 2002].

The entire aforementioned process was performed individually for 5 (five) of the 17 (seventeen) images that compose the mosaic. These five images were chosen based on the lowest georeferencing error. Moreover, the entire process was repeated for the other mosaics generated by the software packages *PhotoScan* and *PhotoModeler*, as illustrated by Figure 4.

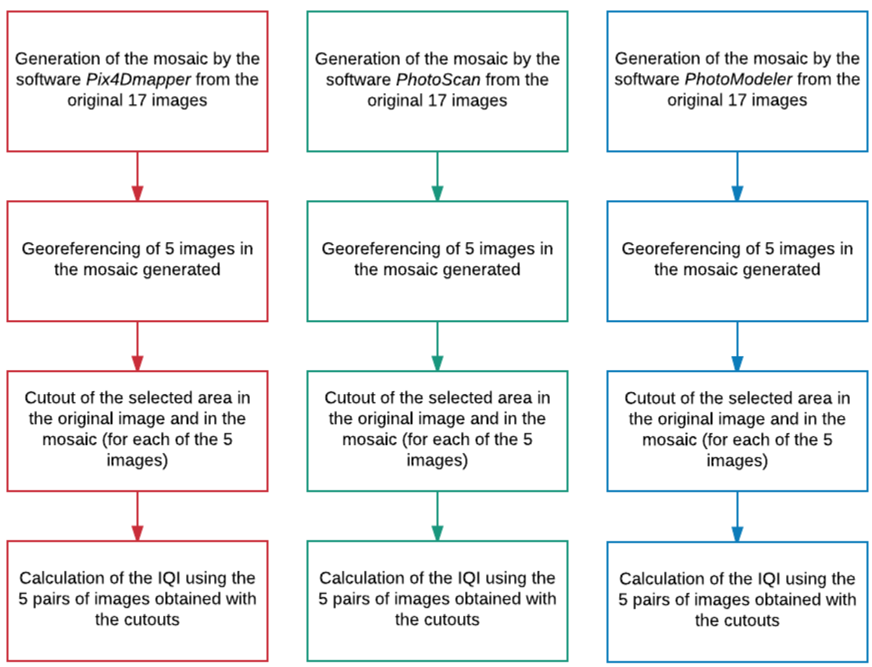


Figure 4. Summary representation of the process performed

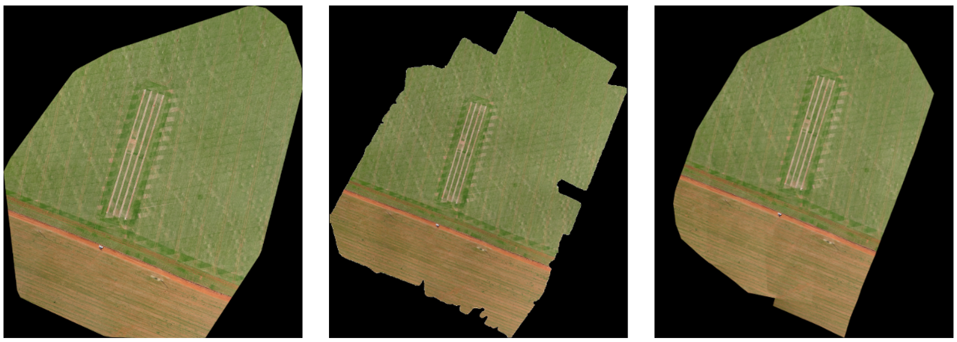
Finally, a single-factor analysis of variance (ANOVA) with significance level of 5% was performed in both means obtained from Root Mean Squared Errors and IQI values.

3. Results and Discussion

Figure 5 shows the three mosaics generated by the software packages *Pix4Dmapper*, *PhotoScan* and *PhotoModeler*, respectively. The mosaic generated by the software *PhotoScan*

[7]https://ece.uwaterloo.ca/ z70wang/research/quality_index/img_qi.m

was superior visually, as it achieved a better use of the images, resulting in a mosaic with a larger area.



(a) Pix4Dmapper (b) PhotoScan (c) PhotoModeler

Figure 5. Mosaics generated

Tables 1, 2 and 3 show the values and the simple averages of the IQIs obtained for each of the 5 (five) cutouts of the original georeferenced images in relation to their respective mosaic cutouts, in addition to the Root Mean Square Errors obtained. Taking into account the conditions of the original images (presented at the beginning of the Section 2), it can be considered that the obtained georeferencing Root Mean Square Errors are insignificant and do not impair the calculation of IQI.

A qualitative evaluation was also made to verify possible misconceptions in the calculation of IQI, that is, values that did not correspond to the real quality of the image; values that could be considered high for low quality images or values that could be considered low for high quality images. This evaluation did not find any kind of discrepancy.

Table 1. Root Mean Square Errors and IQI values - mosaic *Pix4Dmapper*

Image pair	Root Mean Square Error	IQI value
1º	0.0947272	0.9924
2º	0.0240922	0.9252
3º	0.0292935	0.9643
4º	0.0294223	0.9202
5º	0.0495653	0.8607
Averages:	0.0454201	0.93256

Although the visual difference in mosaic quality occurred only in relation to the area of coverage, IQI quantitatively demonstrates that the mosaic generated by the software *PhotoModeler* was better able to preserve the original quality of the images. Only the IQI value of the first pair of images tested in Table 3 was inferior when compared to the same values of Tables 1 and 2.

Table 2. Root Mean Square Errors and IQI values - mosaic *PhotoScan*

Image pair	Root Mean Square Error	IQI value
1º	0.0565836	0.9878
2º	0.0638293	0.9655
3º	0.0745294	0.9860
4º	0.0208178	0.9486
5º	0.1016300	0.8528
Averages:	0.06347802	0.94814

Table 3. Root Mean Square Errors and IQI values - mosaic *PhotoModeler*

Image pair	Root Mean Square Error	IQI value
1º	0.0815671	0.9831
2º	0.0318531	0.9937
3º	0.0798116	0.9889
4º	0.1179040	0.9715
5º	0.0213030	0.9687
Averages:	0.06648776	0.98118

[Ribeiro et al. 2013] used the Image Quality Index to compare multiresolution segmentations with different scale, shape, smoothness, and compactness factors for multispectral, panchromatic, and fusion images by main components and transformation of the RGB-IHS color space. The qualitative evaluation corroborated the results obtained by the quantitative evaluation (IQI calculation), in which the fusion image provides better results in multiresolution segmentation.

Other methods of quantitative (or objective) evaluation of an image can be found in [Wang et al. 2004], [Sheikh and Bovik 2006] and [Sakuldee and Udomhunsakul 2008].

The analysis of variance between the means obtained from the Root Mean Square Errors did not show a significant difference, indicating that this did not affect the calculation of the IQI value for the three mosaics generated. Likewise, the analysis of variance between the means obtained from the IQI values did not present a significant difference, indicating that the quality of the mosaics generated by the three software packages is on the same level.

4. Conclusions

The use of the calculation of the Image Quality Index to evaluate the mosaics generated with images obtained from RPA was effective, supporting and corroborating with the qualitative evaluation done by the observers. The quantitative analysis still does not have the substitute role of the qualitative analysis, but rather a tool to aid the observer to perform the analysis.

Subjective measurement by observer's response is truly definitive, but too inconvenient, time consuming and expensive. Fundamental objective measurements take less time, however they do not correlate well with subjective measurement [Sakuldee and Udomhunsakul 2008].

Although the subjective measurement may still be superior, several studies are done in this area, aiming the development of methods of objective measurement that approach more and more of the qualitative evaluation, saving time and resources.

For future work, the use of Global Navigation Satellite System (GNSS) signal receivers for the collection of coordinates of notable field points recognized in the images may contribute to the evaluation of the mosaics obtained by RPA images.

The increase of applications using remote sensing data acquired through RPA has demonstrated potential in several areas and the evaluation of the quality of the products generated is essential for the applications to represent the proposed efficiency.

References

Capel, D. (2004). Image mosaicing. In *Image Mosaicing and Super-resolution*, pages 47–79. Springer.

Ghosh, D. and Kaabouch, N. (2016). A survey on image mosaicing techniques. *Journal of Visual Communication and Image Representation*, 34:1–11.

Kakaes, K., Greenwood, F., Lippincott, M., Dosemagen, S., Meier, P., and Wich, S. (2015). Drones and aerial observation: New technologies for property rights, human rights, and global development. *New America, Washington, DC, USA, Tech. Rep.*

Li, Z. and Isler, V. (2016). Large scale image mosaic construction for agricultural applications. *IEEE Robotics and Automation Letters*, 1(1):295–302.

Perin, G., Gerke, T., Lacerda, V. S., da Rosa, J. Z., Caires, E. F., and Guimarães, A. M. (2016). Análise de acurácia de georrefereciamento de mosaicos de imagens obtidas por rpa. *VII Encontro Anual de Tecnologia da Informação e VII Simpósio de Tecnologia da Informação da Região Noroeste do RS*.

Ribeiro, S. R. A., Centeno, J. A. S., and La Scalea, R. A. (2013). Segmentações multiresolução em imagens de alta resolução espacial. *Revista Brasileira de Cartografia*, (64/5).

Sakuldee, R. and Udomhunsakul, S. (2008). Objective measurements of distorted image quality evaluation. In *Computer and Communication Engineering, 2008. ICCCE 2008. International Conference on*, pages 1046–1051. IEEE.

Sheikh, H. R. and Bovik, A. C. (2006). Image information and visual quality. *IEEE Transactions on image processing*, 15(2):430–444.

Wang, Z. and Bovik, A. C. (2002). A universal image quality index. *IEEE Signal Processing Letters*, 9(3):81–84.

Wang, Z., Bovik, A. C., Sheikh, H. R., and Simoncelli, E. P. (2004). Image quality assessment: from error visibility to structural similarity. *IEEE transactions on image processing*, 13(4):600–612.