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Stitching Algorithms for Automatic Assembly of Hyperspectral Histological Images

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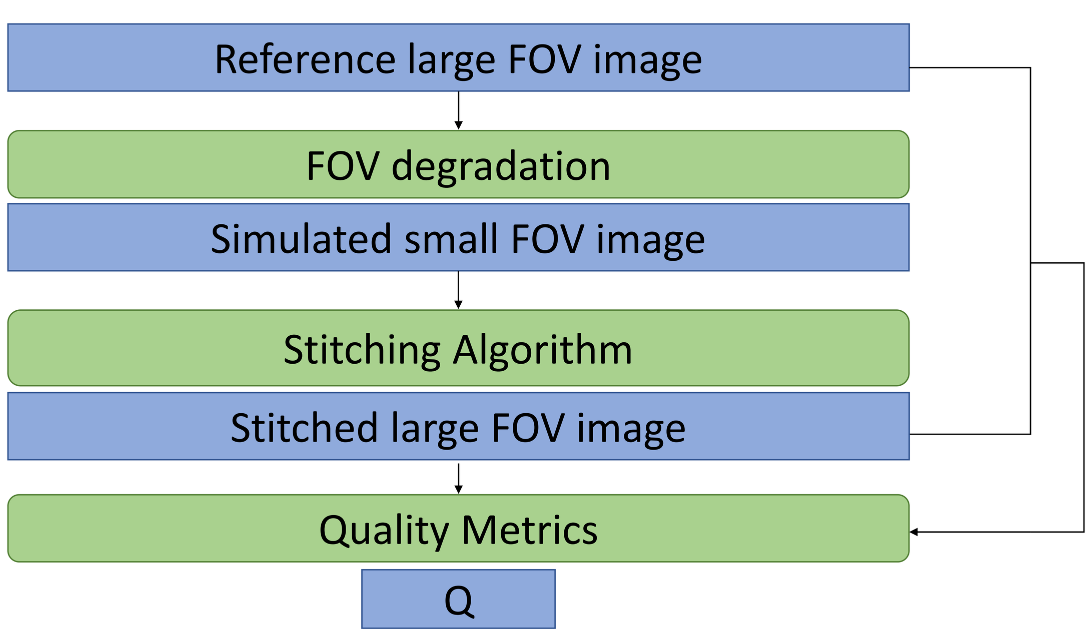
Abstract

- Whole Slide Imaging (WSI) refers to the digitalization of entire histology slides and it is becoming an improvement for pathology workflows. Moreover, hyperspectral imaging (HSI) is an emerging technology in the biomedical field because it can enhance histological disease detection. However, hyperspectral's field of view (FOV) is usually poor. In this work, we describe different methodologies for microimage stitching, offering an approach for the expansion of the FOV of hyperspectral (HS) images while keeping its spatial resolution. The goal is to find the optimal combination of parameters for the input frames of a stitching algorithm.

Keywords: *Hyperspectral imaging (HSI); Computational Pathology; Stitching.*

Methodology

- It was designed a quality assessment protocol based on the one proposed by Wald in 1997 [1].



Field of View Degradation (FOVD)

- The FOV was degraded by a factor of 2 and translational errors were simulated when cropping the small images (Nsi). Additionally, relevant variables included the percentage of overlap and the number of frames (Nf).

$$Overlap = \frac{Nsi - FOVD}{Nsi - 1} \qquad FOVD \leq Nf \leq \frac{overlap - FOVD}{overlap - 1}$$

Stitching Algorithms

- Manual stitching consisted on mosaicking the images one next to each other by hand. Automatic stitching refers to an algorithm, developed by Lang *et al.* [2].

Quality Metrics

- Image quality evaluation can be divided into qualitative, based on human judgment and, quantitative, based on metrics like RMSE (Root-Mean-Square Error), PSNR (Peak Signal-to-Noise Ratio) and SSIM (Structural Similarity Index Measure).

Results

- We obtained the results for the manual stitched images consisting on mosaicking the images one next to each other, without further processing. Quantitatively, metrics were acceptable, however, qualitatively, the image quality was really poor in the unions (Figure 1).
- We obtained the results for the automatic stitched images. Firstly, the most appropriate overlap percentage and the frames employed (Nf) were investigated. For every image, all the overlaps between 50% and 92% were evaluated, and also all the possible number of frames for a certain overlap. We can see an example of a chart obtained for SSIM in Figure 2. Results clearly show the most repeated number of frames to be 3, and the overlap 67% (reconstructs 83% of original image). Secondly, from pre-processed images (159 bands), single band stitching was performed. Then, it was computed the mean for each band (of the 5 brain histology images), as shown in Figure 3. The most accurate stitching results would be given from bands in the range of wavelength 650 to 750 nm.
- Finally, some band configurations were evaluated. Cubes of 10 and 3 bands were conformed using wavelengths between 650 and 750 nm. The mosaics resulting from these cubes offered SSIM values between 0.88 and 0.94.
- Computational resources of this algorithm requires ~0.5 MB of memory and 100 seconds of execution time per each band stitched.

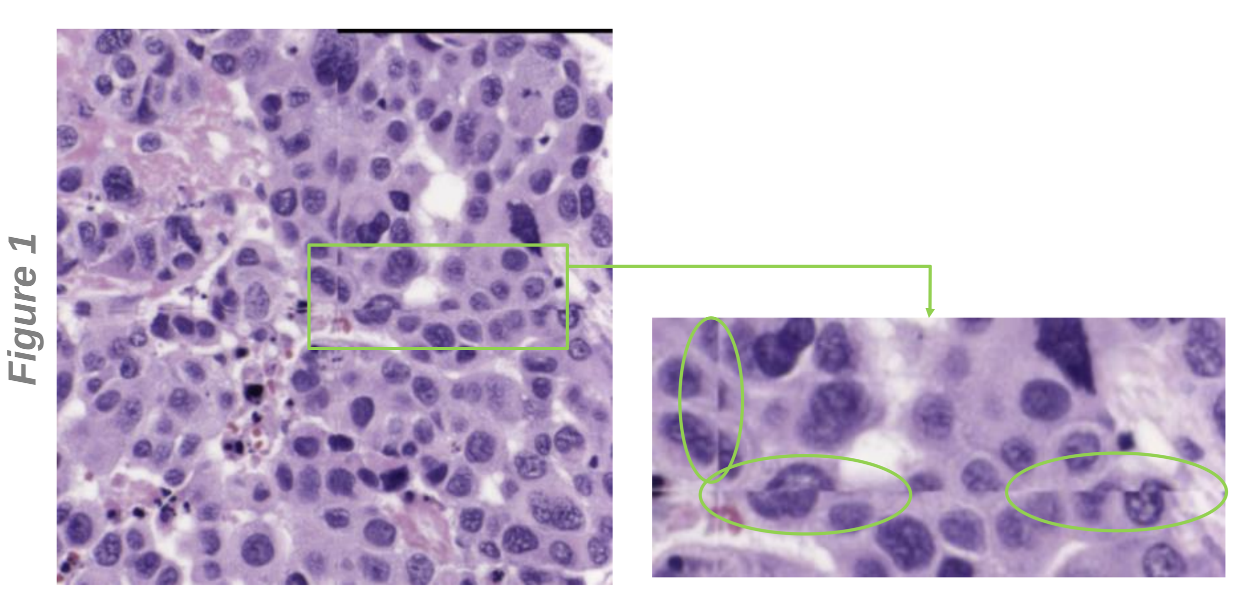


Figure 1

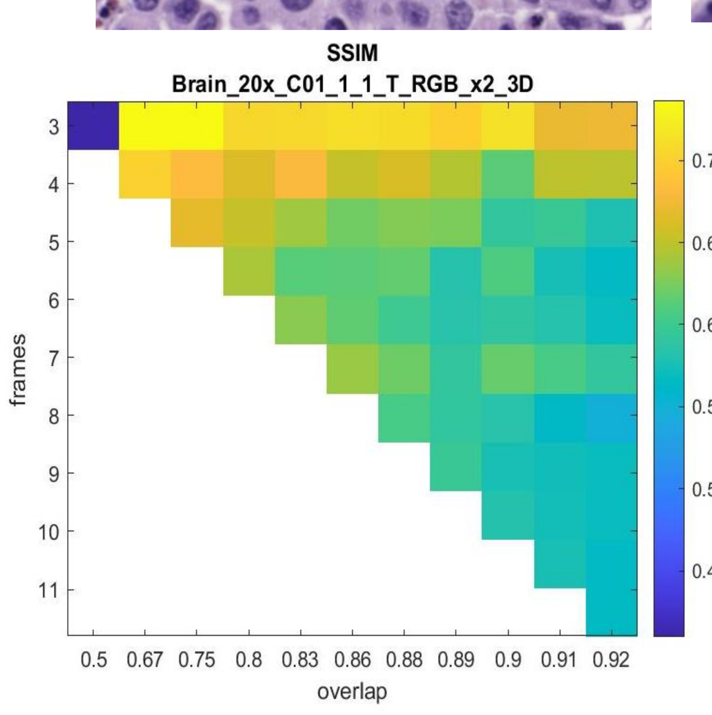


Figure 2

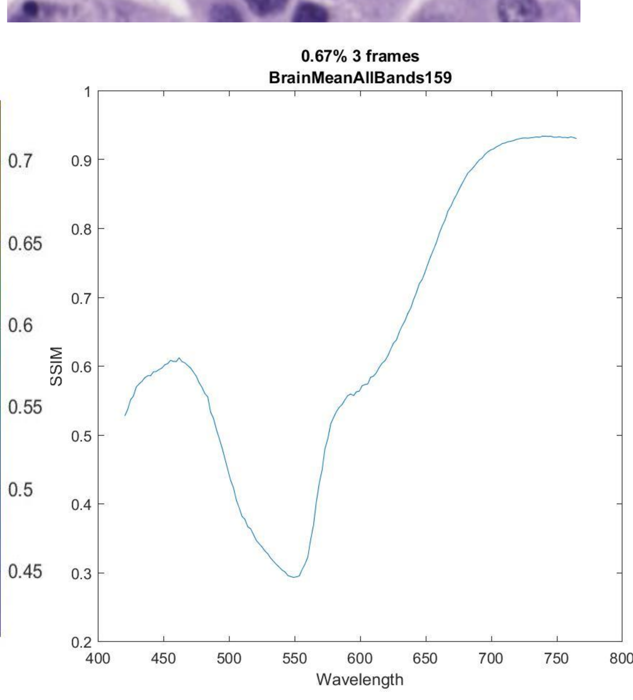


Figure 3

Conclusions

- Although manual stitching showed good quantitative results, the joints between images were not as good. Lang *et al.* algorithm offered good results applying 3 frames at 67% overlap to reconstruct the original image. Single band stitching was also performed, finding a range of wavelength between 650 and 750 nm that provided accurate mosaics. Several combinations of bands within this range were tested and proved to be quantitative and qualitative good.

References

[1] L. Wald, T. Ranchin, and M. Mangolini, "Fusion of satellite images of different spatial resolutions: Assessing the quality of resulting images," Photogram. Eng. Remote Sens., vol. 63, pp. 691–699, 1997
[2] R. T. Lang, J. Tatz, E. M. Kercher, A. Palanisami, D. H. Brooks, and B. Q. Spring, "Multichannel correlation improves the noise tolerance of real-time hyperspectral microimage mosaicking," J. Biomed. Opt., vol. 24, no. 12, p. 1, Dec. 2019, doi: 10.1117/1.JBO.24.12.126002.

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