Quantitative and experimental assessment of optical coherence tomography volumes obtained using non-raster trajectories

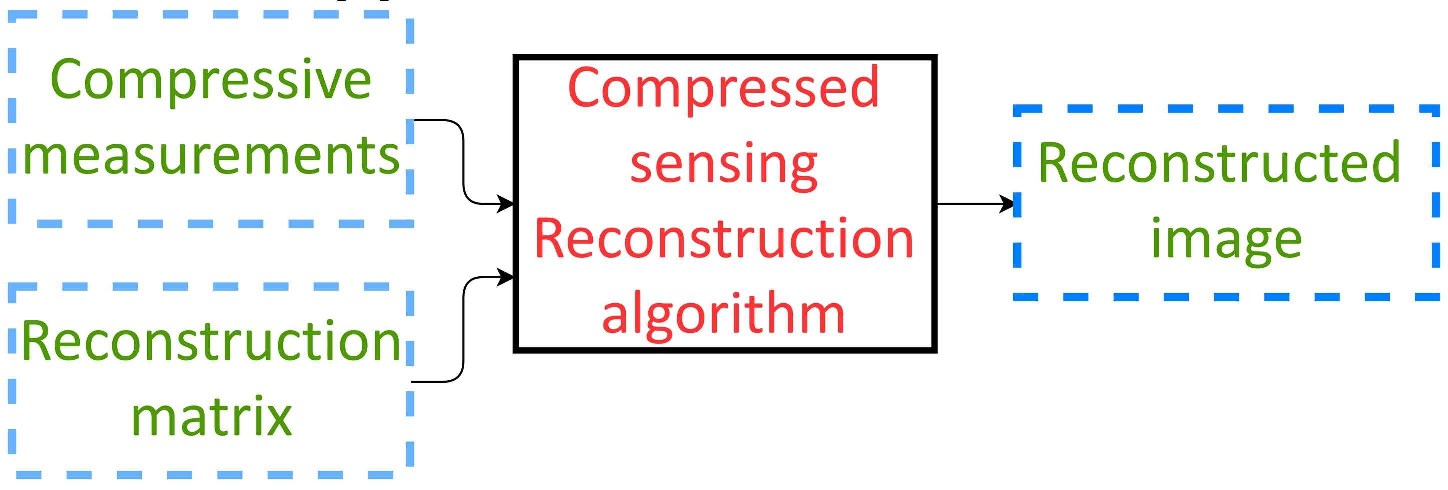
Introduction:

Optical coherence tomography (OCT) is a non-contact, minimally invasive imaging technique which generates high resolution tissue cross-section images. Since it's invention in the 1990s, OCT is now an invaluable diagnostic imaging modality in gastroenterology, ophthalmology etc. Surgeons need high quality images at a fast rate. Much attention to improve OCT acquisition rate has been given by improving the mechanical scanners and increasing computation power through the use of GPUs for image processing and data acquisition. However, an interesting solution to OCT improvement is through software by implementing optimal scanning strategies.

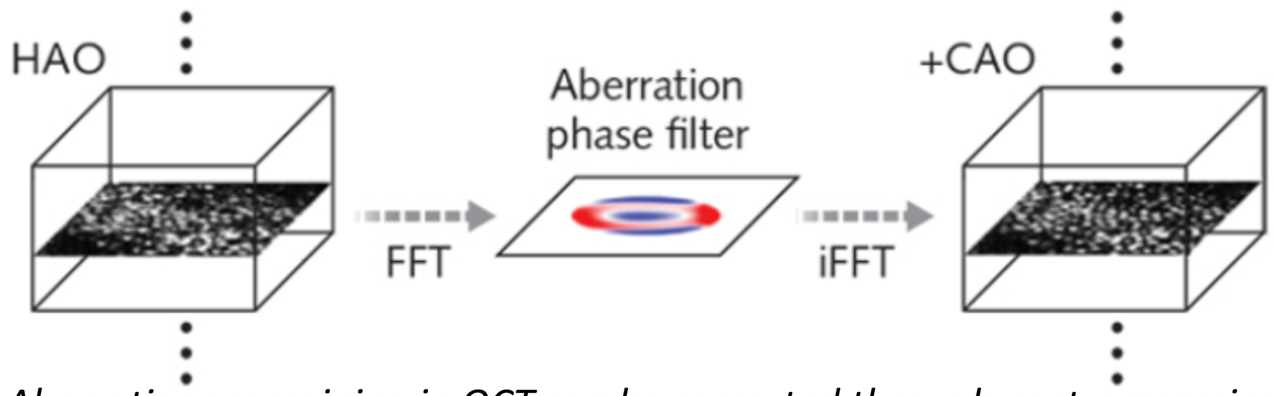
1. State of the art:

Ways of improving OCT imaging quality and faster acquisition include:

- ✓ Compressed sensing - reconstruction of OCT images using less measurement data[1].



- ✓ Increasing the mechanical scan frequency of the mirrors
- ✓ Post-processing methods to enhance image quality
- ✓ Computation OCT



Aberrations remaining in OCT can be corrected through post-processing Using computational adaptive optics(CAO)[2].

❖ Attention has been rarely given to the scanning strategy.

2. Scanning strategies:

Scanning trajectory criteria:

- ✓ Respect the mechanical bandwidth of the scanner
- ✓ Continuous and easily achievable considering kinematic aspects
- ✓ Fast preview of the sample image
- ✓ Optimal data distribution

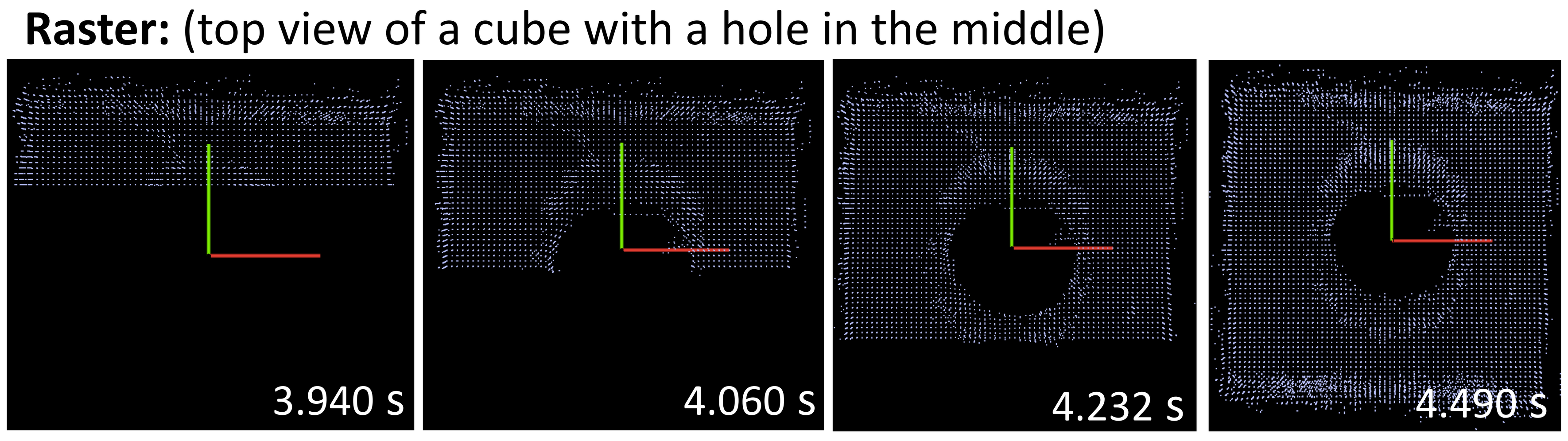
Examples of scanning trajectories; Lissajous, spiral, rosette

3. Criteria for analyzing quality of the scan:

- Time taken in acquiring the volume
- Similarity to the ground truth (subjective and objective comparison)

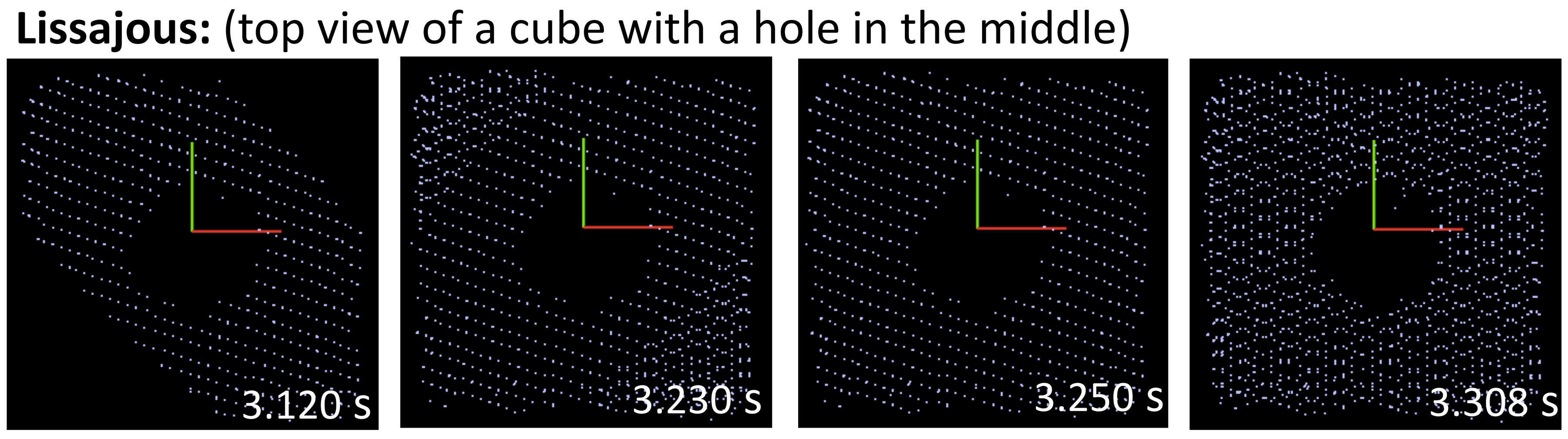
4. Sequential acquisition of raster and Lissajous:

Raster: (top view of a cube with a hole in the middle)



- ✓ The whole image has to be processed for analysis to be done.

Lissajous: (top view of a cube with a hole in the middle)

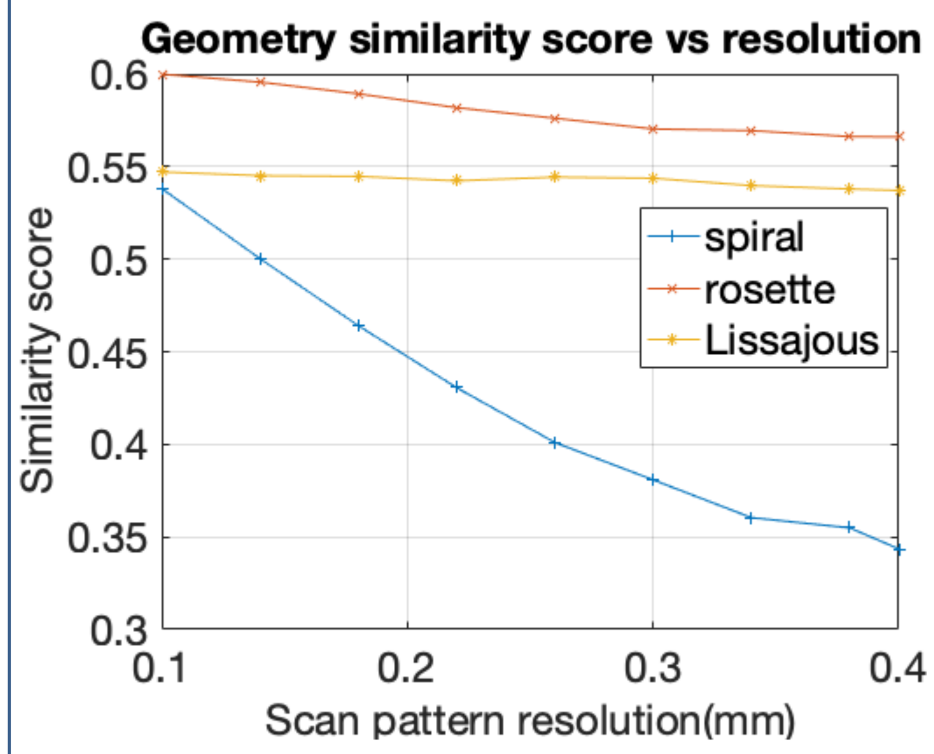


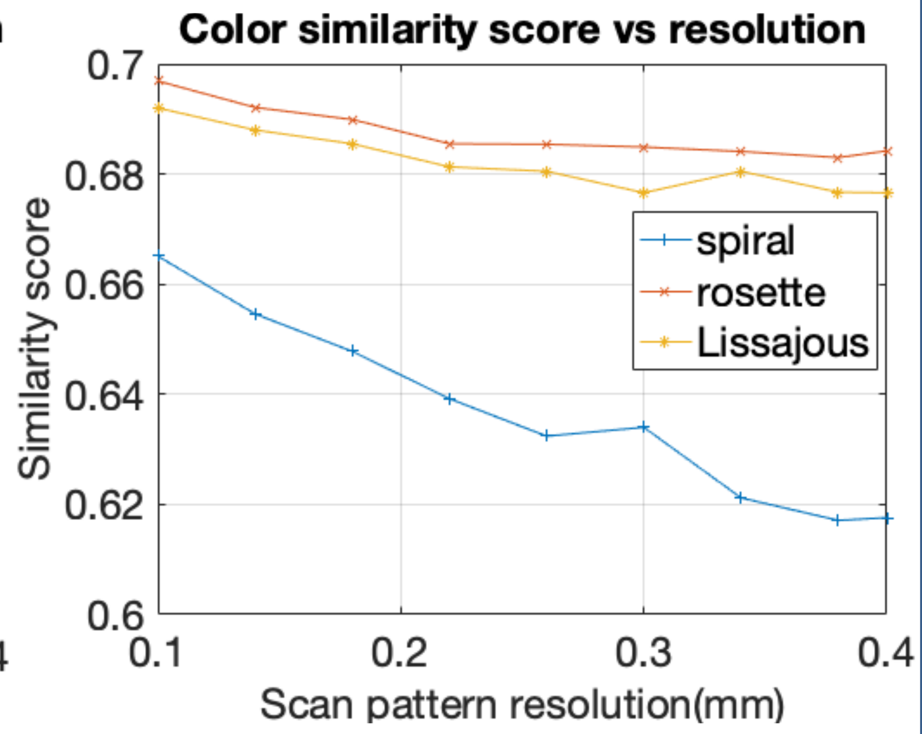
- ✓ Within a short time, a rough preview of the image can be seen.

5. Similarity comparison:

Similarity score: PointSSIM (objective quality metric, full-reference)[3]:

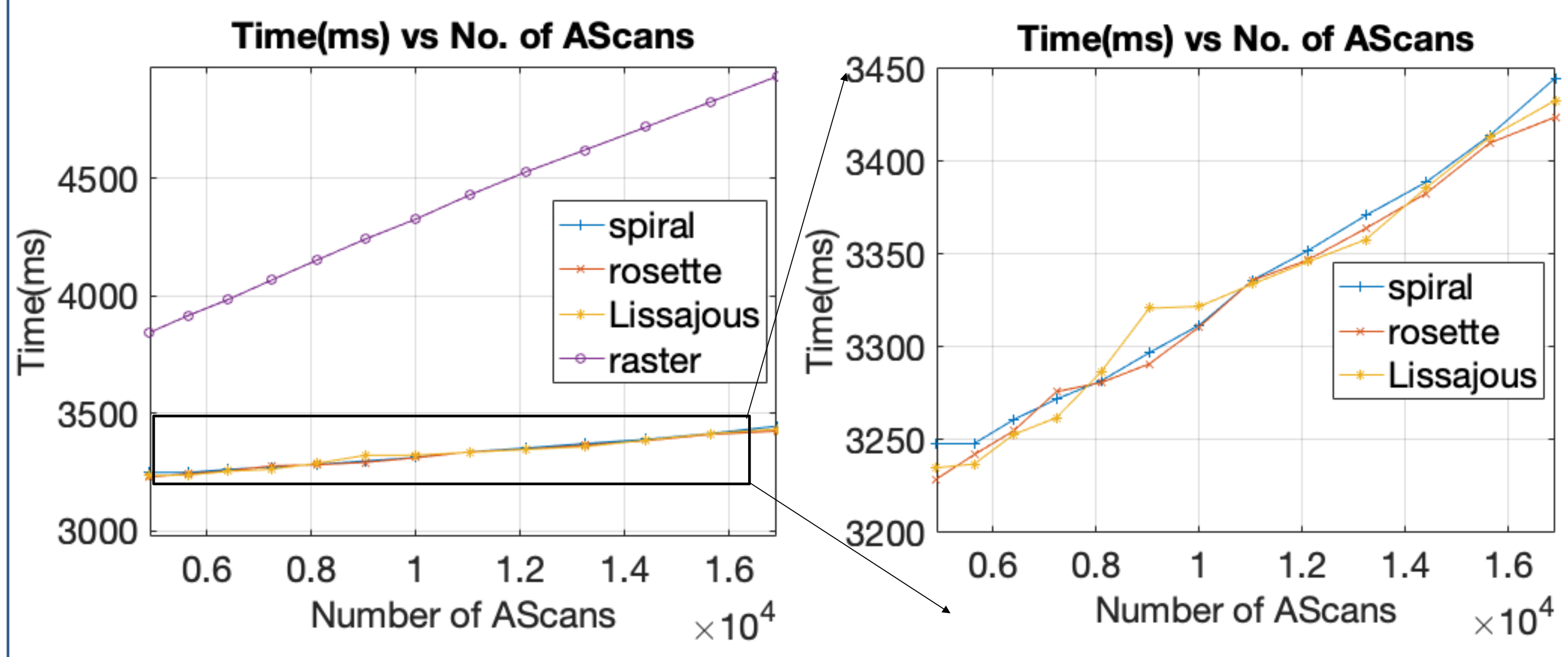
- Geometry
- Color
- Normal vectors
- Curvature





- ✓ Similarity score decreases as the resolution decreases.
- ✓ Rosette pattern is more robust to this decrease.
- ✓ Lissajous has a smoother gradient decrease in the similarity score.

Time analysis:



- ✓ For same number of Ascans, raster is slower than the continuous trajectories.

6. Discussion:

- ✓ Assessment of scanning trajectories using PointSSIM.
- ✓ Better image quality using continuous trajectories.
- ✓ Faster image acquisition using continuous trajectories as compared to raster for similar number of Ascans.
- ✓ Adaptive scanning using continuous trajectories.

7. References:

1. Haydar, B., Chrétien, S., Bartoli, A., & Tamadazte, B. (2020). Three-dimensional OCT Compressed Sensing using the shearlet transform under continuous trajectories sampling. *Informatics in Medicine Unlocked*, *19*. https://doi.org/10.1016/j.imu.2019.100287
2. Liu, Y.-Z., South, F. A., Xu, Y., Carney, P. S., & Boppart, S. A. (2017). Computational optical coherence tomography [Invited]. *Biomedical Optics Express*, *8*(3), 1549. https://doi.org/10/1364/boe.8.001549.
3. Evangelos Alexiou et al. (2020). Towards a Point Cloud Structural Similarity Metric. *IEEE International Conference on Multimedia & Expo Workshops*.

Conclusion:

Assessment of point cloud OCT volumes using the similarity score has been done on the full field of view. It is observed that the similarity score for the Lissajous trajectory decreases at a smoother gradient as compared to the other trajectories, while the rosette has the best quality. It would also be interesting to perform assessment on specific regions on the field of view e.g. the center. Another way to improve the quality of an OCT image is through adaptive scanning. This is whereby scanning is done on selective areas on the sample tissue, such that lesion locations are densely sampled as compared to regions where meaningful data is less. By prioritizing important features in the tissue being scanned, It will facilitate faster and better quality image acquisition in diagnostic procedures.

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