Quantify the Effect of Histogram Intersection in Spatio-Temporal Data Sampling

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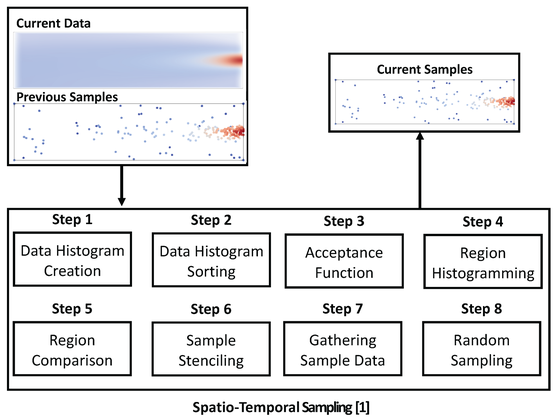
Abstract

- Computational speed is limited by I/O, causing a bottleneck within the system.
- Spatio-temporal sampling reduces the overall data size but is limited by various user inputs, such as histogram threshold.
- We explore the impact of the histogram threshold on Spatio-Temporal sampling over various data sets.
- **Results indicate an increase of 100 - 130% in sampling bandwidth with only a 5 % decrease in PSNR for the ExaAM dataset.**

Spatio-Temporal Sampling



Spatio-Temporal Sampling [1]

The figure above is an overview of the Spatio-temporal sampling process.

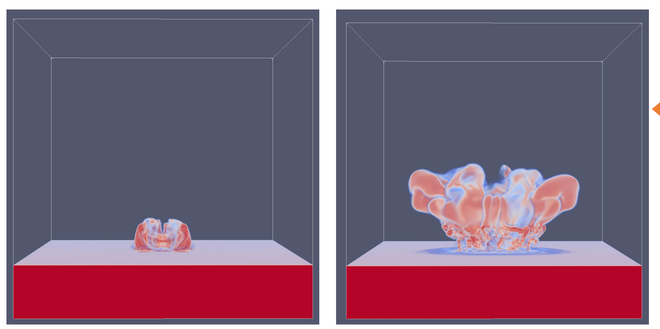
Experimental set up

- Clemson Palmetto Cluster
- 1 NVIDIA V100 GPU
- 1 Intel Xeon 6148G CPU

Methods

Testing begins with setting the 100% histogram intersection as the base case. Then compare the base case results with 0%, 50%, and 90% histogram intersection to determine the succeeding testing percentage until the percent of blocks reused becomes static.

Datasets



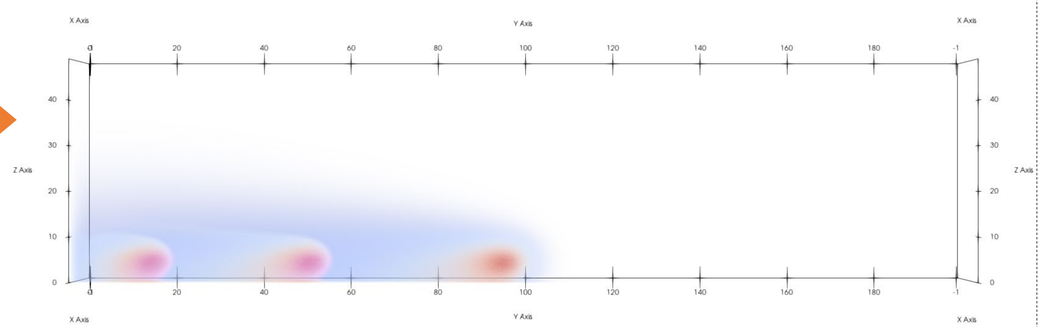
Asteroid Impact dataset at selected timesteps

ExaAM Dataset across few selected timestep

Dataset Dimension

300x300x300

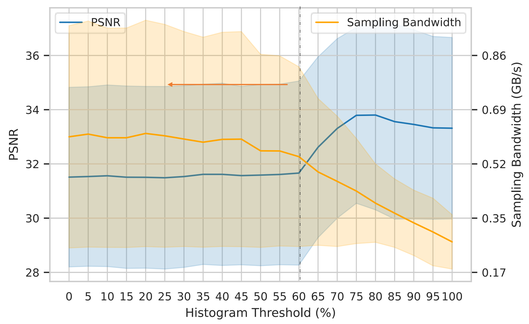
20x200x50

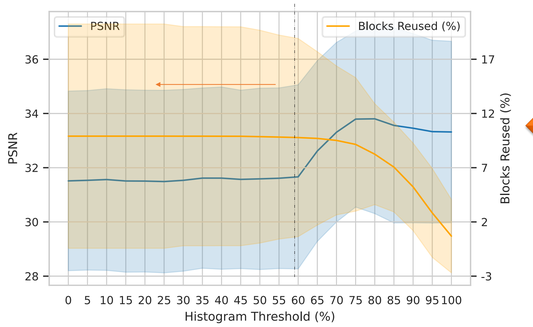


Results

Relationship Between Histogram Threshold and Various Parameters.

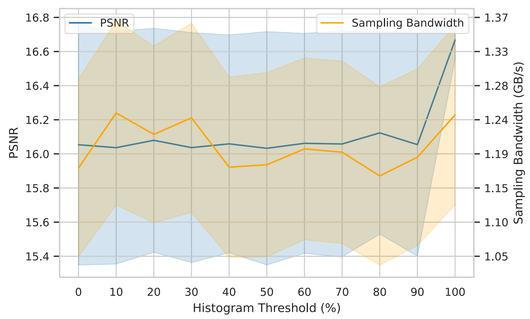
ExaAM Dataset

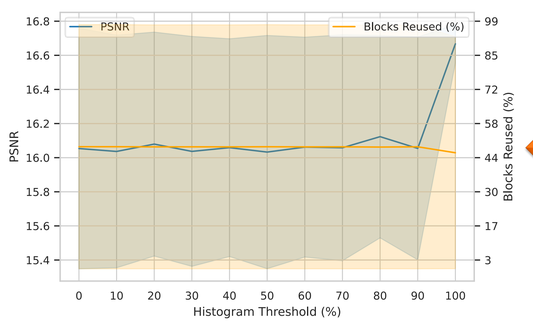




The dotted line indicates the histogram threshold at which the ExaAM dataset has improved the sampling bandwidth by 100%, with only a decrease of 5% in PSNR compared to the base case of 100% histogram intersection.

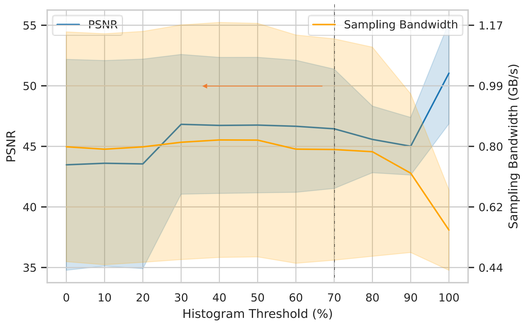
Asteroid Impact Dataset

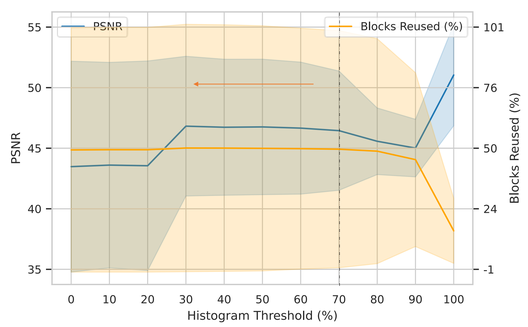




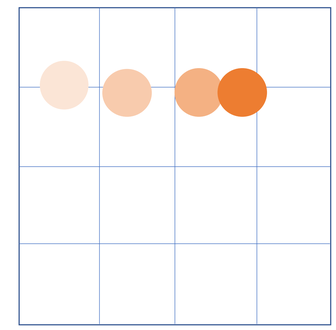
The figure above shows no improvement as the histogram intersection decreases. In fact, for this dataset, in particular, the 100% histogram intersection shows the best result since it is a slow-moving dataset.

Hurricane Dataset





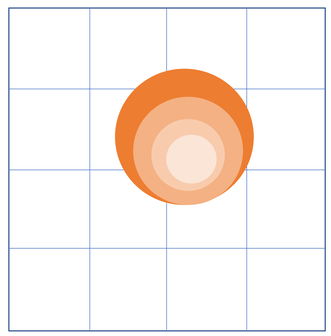
For the figure above, it approaches the maximum blocks reused at the 70% histogram threshold. That is also the most optimum histogram threshold for this dataset. It shows an improvement of 40% in sampling bandwidth with only a 5% decrease in PSNR compared to the base case of 100% histogram intersection.



Fast moving data set

A fast-moving dataset such as the ExaAM dataset moves throughout the time step causing the surroundings to change rapidly. These rapid changes in the surroundings result in the improvement in sampling bandwidth as the histogram threshold decreases.

Time-step 0 1 2 3



Slow moving data set

A slow-moving dataset such as the Impact dataset moves throughout the time step without causing many changes in the surroundings. These lack of changes in the surroundings result in no improvement in sampling bandwidth or PSNR as the histogram threshold decreases.

Conclusion

- Results indicate that the individual dataset limits the improvement of PSNR or sampling bandwidth through the histogram threshold.
- Dataset that falls under the fast-moving categories shows an improvement in sampling bandwidth when histogram intersection decrease. For example, the ExaAM dataset shows an increase of 100-130% for histogram intersections lower than 60%.
- Our methods show that once we approach the static blocks reused region, that is also the region of most optimum histogram intersection.

Acknowledgement

Clemson University is acknowledged for generous allotment of compute time on the Palmetto cluster. This material is based upon work supported by the National Science Foundation under Grant No. SHF-1910197 and SHF-1943114.

Contact

Reference

[1] Megan Hickman Fulp, Dakota Fulp, Ayan Biswas, Meilssa C. Smith, and Jon C. Calhoun. 2022. Accelerated Dynamic Data Reduction Using Spatial and Temporal Properties. The International Journal of High Performance Computing Applications (2022). in submission.