Reordering Tensors for High Performance Applications
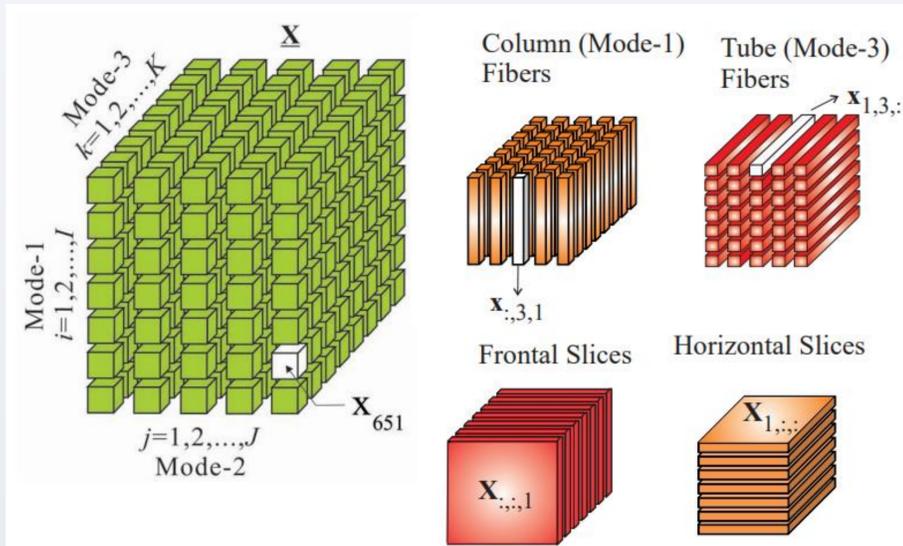
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ABSTRACT

Cichocki, A. (2013)

Tensors –data represented in the form of elements of high dimensional vector spaces- have become popular in various fields such as machine learning and statistics. Considering the size of large data sets, it is of significance to increase the efficiency of tensor analysis methods. In this report, we present our attempts to reorder a tensor; that is, to compute an isomorphism of a tensor such that the non-zero's in the tensor are co-located. This improves the spatial locality of the data and hence increases cache utilization when the tensor data is accessed by various tensor-related operations such as canonical polyadic decomposition computation.

OBJECTIVES

Performing analysis on tensors as they are, results in complex data access patterns and structures; another notable drawback of using tensors as is, is that the data analysis methods suffer from curse of dimensionality. A widely used strategy to improve on this situation is to perform tensor rank decomposition; that is, to decompose the tensor into lower rank structures. The de-facto standard for tensor rank decomposition is the canonical polyadic decomposition (CPD). However, the computation of CPD for a tensor performs non-sequential access to tensor entries. This results in poor cache utilization if the tensor entries are not co-located.

For a tensor $T \in \mathbb{R}^{I_1 \times I_2 \times \dots \times I_k}$ we aim to compute an isomorphism, T', such that non-zero entries of T' are co-located.
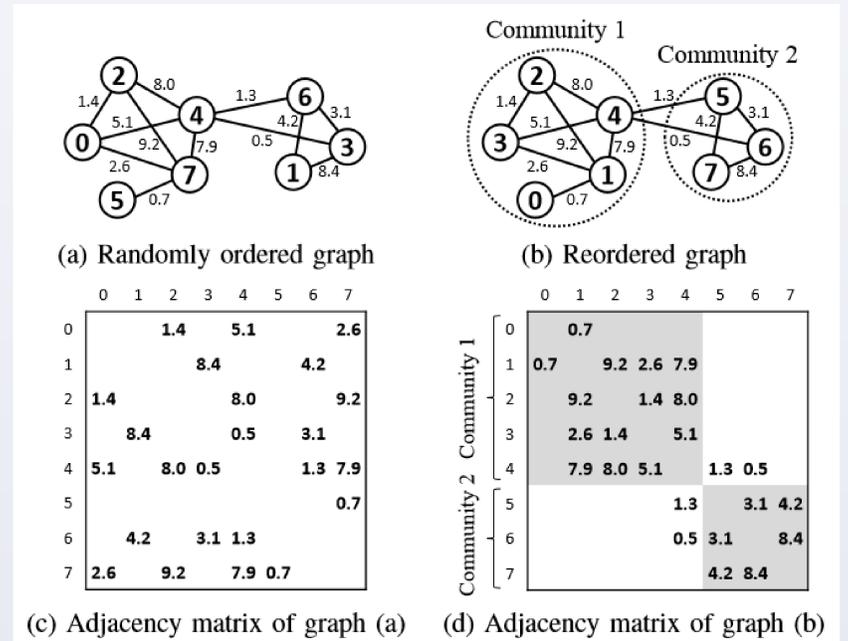
Reordering Sparse Matrices
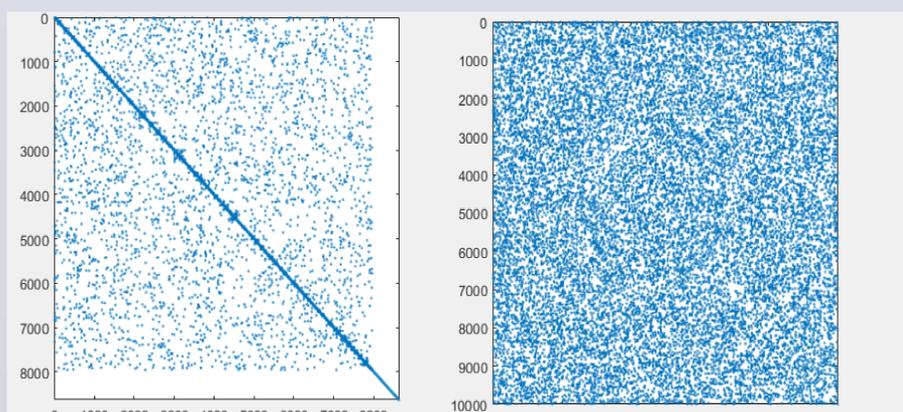
Reordered (left) and natural (right) orderings of the same matrix

Similar locality issues arise for matrices as well. There have been studies such as Arai, J. et al. (2016) have conducted in order to solve this problem. These studies play a major role in our work to reorder tensors.

Reordering Tensors

Arai, J. et al. (2013)

In order to reorder a tensor, the following procedure was followed. First, the tensor is converted into a graph; then, a permutation of vertices of the graph from step 1 is computed. As for the last step, the coordinates of non-zero's of the natural tensor is relabeled with respect to the permutation acquired from the previous step.

We have implemented three sparse matrix reordering algorithms to use in the step two of the procedure described above. The Rabbit Order algorithm and two variants of the reverse Cuthill-Mckee algorithm, one being the degree based variant and the other being the weight based variant.

For the first and the last steps of the procedure we used SPLATT (Smith, Ravindran, Sidiropoulos, Karypis), a utility software providing various tensor operations including reordering and converting tensors.

In order to measure the order of a tensor, we have introduced various mode dependent and mode independent numeric metrics. Our aim is to observe improvements on these metrics after reordering the tensor

CONCLUSIONS

Unfortunately, we were unable to improve on the metrics after the reordering procedure. We suspect that we have not implemented our software with accordance to SPLATT.

Our next steps will be to perform modifications on our software to interpret the data output by SPLATT correctly. We hope to see improvements in the metrics afterwards.

REFERENCES

Arai, J., Shiokawa, H., Yamamuro, T., Onizuka, M., & Iwamura, S. (2016). Rabbit Order: Just-intime Parallel Reordering for Fast Graph Analysis. *IEE International Parallel and Distributed Processing Symposium*, (pp. 22-31). Doi:10.1109

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