

BoBa Tensor Network Library

Category

Software

BoBa is available for U.S. government and authorized U.S. government contractors

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Description

Huge datasets and tables, as well as high-dimensional partial differential equations, are challenging to work with due to their large memory requirements, even by today's standards. This motivates the development of data compression techniques that allow us to work directly with data in its compressed format. The BoBa library aims to provide performance-portable abstractions that enable tensor methods that are low-memory, controllably accurate, and efficient across heterogeneous hardware.

BoBa is a (mostly) header-only C++ library containing algorithms for matrices, tensors, and tensor networks designed for next-generation heterogeneous architectures. It enables the creation of matrix, tensor, and tensor-network algorithms that achieve high performance on both laptops and HPC clusters.

Core Features

At its core, BoBa offers a variety of features for matrices and tensors:

- **Performance portability** across CPUs and GPUs for dense matrix and tensor algebra, including support for CUDA, HIP, and [Eigen](#).
- **Dense, memory-owning object abstractions** for arrays, vectors, matrices, and tensors that follow the "resource allocation is initialization" philosophy.
- Capabilities to create **views** of such objects, including 'atomic' and 'const' views.
- Routines for calling open-source and vendor linear algebra operations, including **LU, QR, SVD**, and more.
- Routines for calling open-source and vendor tensor algebra operations, including **permutations, contractions, reductions**, and more.
- **Portable multi-dimensional loops and reductions** enabled by [RAJA](#).
- **Dense object memory pooling** enabled by [Umpire](#).
- **Static (compile-time sized) versions** of matrices and tensors, with relevant algorithms.
- A **C++17 feature set**, with back-portability to C++14.

Tensor Network Library

Built atop this core functionality is a performance-portable tensor network library that includes:

- Implementations for arbitrary-dimensional **tensor trains, tensor train matrices**, and related algorithms.
- Implementations for arbitrary-dimensional **Tucker decompositions, Tucker matrices**, and related algorithms.
- Implementations for arbitrary-dimensional **multilinear and nonlinear solvers**.
- Tutorials, informative unit tests, and mini-applications related to all of the above.



Applications

The BoBa library has been used in several applications, including:

- **Compressing huge multi-dimensional data tables** found in chemistry and high-energy density physics, and efficiently reading these tables on GPUs.
- **Accelerating high-dimensional Vlasov solvers.**
- **Creating tensorized finite element solvers** using [mfem](#).

Licensing Information

The BoBa code is **Official Use Only, Export-Controlled**, and cannot be shared or redistributed.

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