

## **NVIDIA CUDA-X - GPU-Accelerated Libraries**

CUDA-X is built on top of CUDA. It is a collection of libraries, that compared to CPU-only systems, provide significantly higher performance, across numerous domains.

**Math libraries** help solve compute-intensive applications.

- 1) **cuBLAS** - It supports around 152 standard Basic Linear Algebra subroutines (BLAS). It also supports half-precision and integer matrix multiplication. It supports GEMM performance optimization, supports CUDA streams for concurrent operations.
- 2) **cuFFT** - It supports FFT(Fast Fourier Transform) implementations, that perform up to 10x faster than CPU-only systems.
- 3) **CUDA Math Library** - High-performance math routines optimized. It also has extended trigonometry, exponential functions support. Support for statistics, Floating point data attributes, optimized reciprocal functions.
- 4) **cuRAND** - Generates high-quality random numbers 8x faster using hundreds of processor cores.
- 5) **cuSOLVER** - Provides a collection of dense and sparse direct linear solvers and Eigen solvers. cusolverDN supports Key LAPACK dense solvers. cusolverSP supports sparse direct solvers. cusolverRF supports sparse refactorization solver.
- 6) **cuSPARSE** - Provides GPU-accelerated basic linear algebra subroutines for sparse matrices that perform significantly faster than CPU-only alternatives
- 7) **cuTENSOR** - Tensor linear algebra library providing tensor contraction, reduction, and elementwise operations. Especially used in deep-learning based applications
- 8) **AmgX** - provides up to 10x acceleration to the computationally intense linear solver portion of simulations.

**Parallel Algorithm Libraries** supports highly efficient parallel algorithms. It can also be used with graphs.

- 1) **Thrust** - It supports accelerated sort, scan, transform, and reduction operations. Also, thrust::sort algorithm delivers 5x to 100x faster sorting performance than STL.

**Image and Video Libraries** support image and video decoding, encoding, and processing.

- 1) **nvJPEG** - Library for decoding, encoding, and transcoding JPEG format images.
- 2) **NVIDIA Video Codec SDK** - library for hardware-based encoding and decoding video and other streams
- 3) **NVIDIA Optical Flow SDK** - dedicated to computing the relative motion of pixels between images. The hardware uses sophisticated algorithms to yield highly accurate flow vectors.

**Communication Libraries** provide multi-node communication primitives.

- 1) **NVSHMEM** - A parallel programming interface that provides efficient and scalable communication.
- 2) **NCCL** - supports multi-node communications that maximize bandwidth while maintaining low latency.

**Deep Learning Libraries** support Deep Learning applications that leverage CUDA and specialized hardware components of GPUs.

- 1) **NVIDIA cuDNN** - library of primitives for Deep Neural Networks
- 2) **NVIDIA TensorRT** - supports high-performance deep learning inference optimizer and runtime for production deployment.
- 3) **NVIDIA Jarvis** - Platform for developing engaging and contextual AI-powered conversation apps
- 4) **NVIDIA DeepStream SDK** - Real-time streaming analytics toolkit for AI-based video understanding and multi-sensor processing.
- 5) **NVIDIA DALI** - decoding and augmenting images and videos to accelerate deep learning applications

**Partner Libraries** (External support)

- 1) **OpenCV** - library for computer vision, image processing, and machine learning.
- 2) **FFmpeg** - multimedia framework with a library of plugins for audio and video processing
- 3) **ArrayFire** - library for matrix, signal, and image processing
- 4) **MAGMA** - linear algebra routines for heterogeneous architectures
- 5) **IMSL Fortran Numerical Library** - Fortran library with functions for math, signal, and image processing, statistics
- 6) **Gunrock** - Library for graph-processing
- 7) **CHOLMOD** - functions for sparse direct solvers
- 8) **Triton Ocean SDK** - Real-time visual simulation of oceans, water bodies in games, simulation, and training applications
- 9) **CUVlib** - Accelerating imaging applications.