Release Notes

Release 12.1.1

NVIDIA

May 23, 2023

Contents

NVIDIA CUDA Toolkit Release Notes

The Release Notes for the CUDA Toolkit.

The release notes for the NVIDIA® CUDA® Toolkit can be found online at https://docs.nvidia.com/cuda/cuda-toolkit-release-notes/index.html.

Note: The release notes have been reorganized into two major sections: the general CUDA release notes, and the CUDA libraries release notes including historical information for 12.x releases.

Chapter 1. CUDA Toolkit Major Component Versions

CUDA Components Starting with CUDA 11, the various components in the toolkit are versioned independently.

For CUDA 12.1 Update 1, the table below indicates the versions:

Table 1: Table 1. CUDA 12.1 Update 1 Component Versions

Component Name		Version Information	Supported Architectures	Supported Platforms
CUDA C++ Core Compute Libraries	Thrust	2.0.1	x86_64, POWER, aarch64-jetson	Linux, Windows
	CUB	2.0.1		
	libcu++	1.9.0		
	Cooperative Groups	12.0.0		
CUDA Compatibility		12.1.32956252	x86_64, POWER, aarch64-jetson	Linux, Windows
CUDA Runtime (cudart)		12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
cuobjdump		12.1.111	x86_64, POWER, aarch64-jetson	Linux, Windows
CUPTI		12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuxxfilt (demangler)		12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows
CUDA Demo Suite		12.1.105	x86_64	Linux, Windows
CUDA GDB		12.1.105	x86_64, POWER, aarch64-jetson	Linux, WSL
CUDA Nsight Eclipse Plugin		12.1.105	x86_64, POWER	Linux
CUDA NVCC		12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL

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Component Name	Version Information	Supported Architectures	Supported Platforms
CUDA nvdisasm	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows
CUDA NVML Headers	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA nvprof	12.1.105	x86_64, POWER	Linux, Windows
CUDA nvprune	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NVRTC	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
NVTX	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NVVP	12.1.105	x86_64, POWER	Linux, Windows
CUDA OpenCL	12.1.105	x86_64	Linux, Windows
CUDA Profiler API	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA Compute Sanitizer API	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuBLAS	12.1.3.1	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuDLA	12.1.105	aarch64-jetson	Linux
CUDA cuFFT	11.0.2.54	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuFile	1.6.1.9	x86_64	Linux
CUDA cuRAND	10.3.2.106	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuSOLVER	11.4.5.107	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuSPARSE	12.1.0.106	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NPP	12.1.0.40	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA nvJitLink	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA nvJPEG	12.2.0.2	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NVVM Samples	12.1.105	x86_64, POWER, aarch64-jetson	Linux, Windows

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Table 1 – continued from previous page

Component Name	Version Information	Supported Architectures	Supported Platforms
Nsight Compute	2023.1.1.4	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL (Windows 11)
Nsight Systems	2023.1.2.43	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
Nsight Visual Studio Edition (VSE)	2023.1.1.23089	x86_64 (Windows)	Windows
nvidia_fs[1]	2.15.3	x86_64, aarch64-jetson	Linux
Visual Studio Integration	12.1.105	x86_64 (Windows)	Windows
NVIDIA Linux Driver	530.30.02	x86_64, POWER, aarch64-jetson	Linux
NVIDIA Windows Driver	531.14	x86_64 (Windows)	Windows, WSL

CUDA Driver Running a CUDA application requires the system with at least one CUDA capable GPU and a driver that is compatible with the CUDA Toolkit. See Table 3. For more information various GPU products that are CUDA capable, visit https://developer.nvidia.com/cuda-gpus.

Each release of the CUDA Toolkit requires a minimum version of the CUDA driver. The CUDA driver is backward compatible, meaning that applications compiled against a particular version of the CUDA will continue to work on subsequent (later) driver releases.

More information on compatibility can be found at https://docs.nvidia.com/cuda/cuda-c-best-practices-guide/index.html#cuda-compatibility-and-upgrades.

Note: Starting with CUDA 11.0, the toolkit components are individually versioned, and the toolkit itself is versioned as shown in the table below.

The minimum required driver version for CUDA minor version compatibility is shown below. CUDA minor version compatibility is described in detail in https://docs.nvidia.com/deploy/cuda-compatibility/index.html

[1] Only available on select Linux distros

Table 2: Table 2. CUDA Toolkit and Minimum Required Driver Version for CUDA Minor Version Compatibility

CUDA Toolkit	Minimum Required Driver Version for CUDA Minor Version Compatibility*	
	Linux x86_64 Driver Version	Windows x86_64 Driver Version
CUDA 12.1.x	>=525.60.13	>=527.41
CUDA 12.0.x	>=525.60.13	>=527.41
CUDA 11.8.x	>=450.80.02	>=452.39
CUDA 11.7.x	>=450.80.02	>=452.39
CUDA 11.6.x	>=450.80.02	>=452.39
CUDA 11.5.x	>=450.80.02	>=452.39
CUDA 11.4.x	>=450.80.02	>=452.39
CUDA 11.3.x	>=450.80.02	>=452.39
CUDA 11.2.x	>=450.80.02	>=452.39
CUDA 11.1 (11.1.0)	>=450.80.02	>=452.39
CUDA 11.0 (11.0.3)	>=450.36.06**	>=451.22**

* Using a Minimum Required Version that is **different** from Toolkit Driver Version could be allowed in compatibility mode – please read the CUDA Compatibility Guide for details.

** CUDA 11.0 was released with an earlier driver version, but by upgrading to Tesla Recommended Drivers 450.80.02 (Linux) / 452.39 (Windows), minor version compatibility is possible across the CUDA 11.x family of toolkits.

The version of the development NVIDIA GPU Driver packaged in each CUDA Toolkit release is shown below.

Table 3: Table 3. CUDA Toolkit and Corresponding Driver Versions

CUDA Toolkit	Toolkit Driver Version	
	Linux x86_64 Driver Version	Windows x8
CUDA 12.1 Update 1	>=530.30.02	>=531.14
CUDA 12.1 GA	>=530.30.02	>=531.14
CUDA 12.0 Update 1	>=525.85.12	>=528.33
CUDA 12.0 GA	>=525.60.13	>=527.41
CUDA 11.8 GA	>=520.61.05	>=520.06
CUDA 11.7 Update 1	>=515.48.07	>=516.31
CUDA 11.7 GA	>=515.43.04	>=516.01
CUDA 11.6 Update 2	>=510.47.03	>=511.65
CUDA 11.6 Update 1	>=510.47.03	>=511.65

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CUDA Toolkit	Toolkit Driver Version	
CUDA 11.6 GA	>=510.39.01	>=511.23
CUDA 11.5 Update 2	>=495.29.05	>=496.13
CUDA 11.5 Update 1	>=495.29.05	>=496.13
CUDA 11.5 GA	>=495.29.05	>=496.04
CUDA 11.4 Update 4	>=470.82.01	>=472.50
CUDA 11.4 Update 3	>=470.82.01	>=472.50
CUDA 11.4 Update 2	>=470.57.02	>=471.41
CUDA 11.4 Update 1	>=470.57.02	>=471.41
CUDA 11.4.0 GA	>=470.42.01	>=471.11
CUDA 11.3.1 Update 1	>=465.19.01	>=465.89
CUDA 11.3.0 GA	>=465.19.01	>=465.89
CUDA 11.2.2 Update 2	>=460.32.03	>=461.33
CUDA 11.2.1 Update 1	>=460.32.03	>=461.09
CUDA 11.2.0 GA	>=460.27.03	>=460.82
CUDA 11.1.1 Update 1	>=455.32	>=456.81
CUDA 11.1 GA	>=455.23	>=456.38
CUDA 11.0.3 Update 1	>= 450.51.06	>= 451.82
CUDA 11.0.2 GA	>= 450.51.05	>= 451.48
CUDA 11.0.1 RC	>= 450.36.06	>= 451.22
CUDA 10.2.89	>= 440.33	>= 441.22
CUDA 10.1 (10.1.105 general release, and updates)	>= 418.39	>= 418.96
CUDA 10.0.130	>= 410.48	>= 411.31
CUDA 9.2 (9.2.148 Update 1)	>= 396.37	>= 398.26
CUDA 9.2 (9.2.88)	>= 396.26	>= 397.44
CUDA 9.1 (9.1.85)	>= 390.46	>= 391.29
CUDA 9.0 (9.0.76)	>= 384.81	>= 385.54
CUDA 8.0 (8.0.61 GA2)	>= 375.26	>= 376.51
CUDA 8.0 (8.0.44)	>= 367.48	>= 369.30
CUDA 7.5 (7.5.16)	>= 352.31	>= 353.66
CUDA 7.0 (7.0.28)	>= 346.46	>= 347.62

For convenience, the NVIDIA driver is installed as part of the CUDA Toolkit installation. Note that this driver is for development purposes and is not recommended for use in production with Tesla GPUs.

For running CUDA applications in production with Tesla GPUs, it is recommended to download the latest driver for Tesla GPUs from the NVIDIA driver downloads site at https://www.nvidia.com/drivers.

During the installation of the CUDA Toolkit, the installation of the NVIDIA driver may be skipped on Windows (when using the interactive or silent installation) or on Linux (by using meta packages).

For more information on customizing the install process on Windows, see https://docs.nvidia.com/cuda/cuda-installation-guide-microsoft-windows/index.html#install-cuda-software.

For meta packages on Linux, see https://docs.nvidia.com/cuda/cuda-installation-guide-linux/index.html#package-manager-metas.

Chapter 2. New Features

This section lists new general CUDA and CUDA compilers features.

2.1. General CUDA New Features

12.1

- New meta-packages for Linux installation.
  - `cuda-toolkit`
    - Installs all CUDA Toolkit packages required to develop CUDA applications.
    - Handles upgrading to the latest version of CUDA when it's released.
    - Does not include the driver.
  - `cuda-toolkit-12`
    - Installs all CUDA Toolkit packages required to develop CUDA applications.
    - Handles upgrading to the next 12.x version of CUDA when it's released.
    - Does not include the driver.
- New CUDA API to enable mini core dump programmatically is now available. Refer to https://docs.nvidia.com/cuda/cuda-gdb/index.html#gpu-core-dump-support and https://docs.nvidia.com/cuda/cuda-driver-api/group__CUDA__COREDUMP.html#group__CUDA__COREDUMP for more information.

2.2. CUDA Compilers New Features

12.1

- NVCC has added support for host compiler: GCC 12.2, NVC++ 22.11, Clang 15.0, VS2022 17.4
- Breakpoint and single stepping behavior for a multi-line statement in device code has been improved, when code is compiled with nvcc using gcc/clang host compiler compiler or when compiled with NVRTC on non-Windows platforms. The debugger will now correctly breakpoint and single-step on each source line of the multiline source code statement.
- PTX has exposed a new special register in the public ISA, which can be used to query total size of shared memory which includes user shared memory and SW reserved shared memory.

- NVCC and NVRTC now show preprocessed source line and column info in a diagnostic to help users to understand the message and identify the issue causing the diagnostic. The source line and column info can be turned off with `--brief-diagnostics=true`.

2.3. CUDA Developer Tools New Features

- For changes to nvprof and Visual Profiler, see the changelog.
- For new features, improvements, and bug fixes in CUPTI, see the changelog.
- For new features, improvements, and bug fixes in Nsight Compute, see the changelog.
- For new features, improvements, and bug fixes in Compute Sanitizer, see the changelog.
- For new features, improvements, and bug fixes in CUDA-GDB, see the changelog.

Chapter 3. Resolved Issues

3.1. CUDA Tools Resolved Issues

12.1 Update 1

- Resolved the following security issues:
  - CVE-2023-25510 NVIDIA CUDA Toolkit SDK for Linux and Windows contains a NULL pointer dereference in cuobjdump, where a local user running the tool against a malformed binary may cause a limited denial of service.
  - CVE-2023-25511 NVIDIA CUDA Toolkit for Linux and Windows contains a vulnerability in cuobjdump, where a division-by-zero error may enable a user to cause a crash, which may lead to a limited denial of service.
  - CVE-2023-25512 NVIDIA CUDA toolkit for Linux and Windows contains a vulnerability in cuobjdump, where an attacker may cause an out-of-bounds memory read by running cuobjdump on a malformed input file. A successful exploit of this vulnerability may lead to denial of service, code execution, and information disclosure.
  - CVE-2023-25513 NVIDIA CUDA toolkit for Linux and Windows contains a vulnerability in cuobjdump, where an attacker may cause an out-of-bounds read by tricking a user into running cuobjdump on a malformed input file. A successful exploit of this vulnerability may lead to denial of service, code execution, and information disclosure.
  - CVE-2023-25514 NVIDIA CUDA toolkit for Linux and Windows contains a vulnerability in cuobjdump, where an attacker may cause an out-of-bounds read by tricking a user into running cuobjdump on a malformed input file. A successful exploit of this vulnerability may lead to denial of service, code execution, and information disclosure.

3.2. CUDA Compilers Resolved Issues

12.1 Update 1

- Fixed an issue in nvcc related to processing of ternary operator ('?') in C++20 concept definition, which was causing compilation failure for <ranges> header when using the `cl.exe` host compiler.

Chapter 4. Deprecated or Dropped Features

Features deprecated in the current release of the CUDA software still work in the current release, but their documentation may have been removed, and they will become officially unsupported in a future release. We recommend that developers employ alternative solutions to these features in their software.

General CUDA

- None.

CUDA Tools

- None.

CUDA Compiler

- None.

Chapter 5. Known Issues

5.1. General CUDA Known Issues

- For a cross-compile toolkit (such as linux64 host, aarch64 target), we are missing the host-side stub library for libnvJitLink. As a workaround, you can copy the `libnvJitlink.so` from the target install (for example, `/usr/local/cuda-12.1/targets/aarch64-linux/lib/libnvJitLink.so`) to the host install (`/usr/local/cuda-12.1/targets/aarch64-linux/lib/stubs/libnvJitLink.so`). Similarly if you are using the static library version (`/usr/local/cuda-12.1/targets/aarch64-linux/lib/libnvJitLink_static.a`), can copy it from the target install (i.e. install on the device) to the same path on the host install. For a sbsa cross-compile replace `aarch64` with `sbsa` in the above copies.
- Due to an issue in the way CUDA processes memory attachment for NVLink multicast allocations, memory must be aligned to 512MB. Alignments below this will result in a failure to attach and an error issued by the driver.

5.2. CUDA Compiler Known Issues

- nvJitLink static and stub library for dynamic linking are not part of the cross-compilation builds of Aarch64-Jetson and arm64-sbsa. This will be resolved in a future release.

Chapter 6. CUDA Libraries

This section covers CUDA Libraries release notes for 12.x releases.

- CUDA Math Libraries toolchain uses C++11 features, and a C++11-compatible standard library (libstdc++ >= 20150422) is required on the host.
- Support for the following compute capabilities is removed for all libraries:
  - sm_35 (Kepler)
  - sm_37 (Kepler)

6.1. cuBLAS Library

6.1.1. cuBLAS: Release 12.1 Update 1

- **New Features**
  - Support for FP8 on NVIDIA Ada GPUs.
  - Improved performance on NVIDIA L4 Ada GPUs.
  - Introduced an API that instructs the cuBLASLt library to not use some CPU instructions. This is useful in some rare cases where certain CPU instructions used by cuBLASLt heuristics negatively impact CPU performance. Refer to https://docs.nvidia.com/cuda/cublas/index. html#disabling-cpu-instructions.
- **Known Issues**
  - When creating a matrix layout using the `cublasLtMatrixLayoutCreate()` function, the object pointed at by `cublasLtMatrixLayout_t` is smaller than `cublasLtMatrixLayoutOpaque_t` (but enough to hold the internal structure). As a result, the object should not be dereferenced or copied explicitly, as this might lead to out of bound accesses. If one needs to serialize the layout or copy it, it is recommended to manually allo-cate an object of size `sizeof(cublasLtMatrixLayoutOpaque_t)` bytes, and initial-ize it using `cublasLtMatrixLayoutInit()` function. The same applies to `cublasLt-MatmulDesc_t` and `cublasLtMatrixTransformDesc_t`. The issue will be fixed in future releases by ensuring that `cublasLtMatrixLayoutCreate()` allocates at least `sizeof(cublasLtMatrixLayoutOpaque_t)` bytes.

6.1.2. cuBLAS: Release 12.0 Update 1

- **New Features**
  - Improved performance on NVIDIA H100 SXM and NVIDIA H100 PCIe GPUs.
- **Known Issues**
  - For optimal performance on NVIDIA Hopper architecture, cuBLAS needs to allocate a bigger internal workspace (64 MiB) than on the previous architectures (8 MiB). In the current and previous releases, cuBLAS allocates 256 MiB. This will be addressed in a future release. A possible workaround is to set the `CUBLAS_WORKSPACE_CONFIG` environment variable to :32768:2 when running cuBLAS on NVIDIA Hopper architecture.
- **Resolved Issues**
  - Reduced cuBLAS host-side overheads caused by not using the cublasLt heuristics cache. This began in the CUDA Toolkit 12.0 release.
  - Added forward compatible single precision complex GEMM that does not require workspace.

6.1.3. cuBLAS: Release 12.0

- **New Features**
  - `cublasLtMatmul` now supports FP8 with a non-zero beta.
  - Added `int64` APIs to enable larger problem sizes; refer to 64-bit integer interface.
  - Added more Hopper-specific kernels for `cublasLtMatmul` with epilogues:
    - `CUBLASLT_EPILOGUE_BGRAD{A,B}`
    - `CUBLASLT_EPILOGUE_{RELU,GELU}_AUX`
    - `CUBLASLT_EPILOGUE_D{RELU,GELU}`
  - Improved Hopper performance on arm64-sbsa by adding Hopper kernels that were previously supported only on the x86_64 architecture for Windows and Linux.
- **Known Issues**
  - There are no forward compatible kernels for single precision complex gemms that do not require workspace. Support will be added in a later release.
- **Resolved Issues**
  - Fixed an issue on NVIDIA Ampere architecture and newer GPUs where `cublasLtMatmul` with epilogue `CUBLASLT_EPILOGUE_BGRAD{A,B}` and a nontrivial reduction scheme (that is, not `CUBLASLT_REDUCTION_SCHEME_NONE`) could return incorrect results for the bias gradient.
  - `cublasLtMatmul` for gemv-like cases (that is, m or n equals 1) might ignore bias with the `CUBLASLT_EPILOGUE_RELU_BIAS` and `CUBLASLT_EPILOGUE_BIAS` epilogues.

  Deprecations
  - Disallow including `cublas.h` and `cublas_v2.h` in the same translation unit.
  - Removed:

- CUBLAS_MATMUL_STAGES_16x80 and CUBLAS_MATMUL_STAGES_64x80 from cublasLtMatmulStages_t. No kernels utilize these stages anymore.
- cublasLt3mMode_t, CUBLASLT_MATMUL_PREF_MATH_MODE_MASK, and CUBLASLT_MATMUL_PREF_GAUSSIAN_MODE_MASK from cublasLtMatmulPreferenceAttributes_t. Instead, use the corresponding flags from cublasLtNumericalImplFlags_t.
- CUBLASLT_MATMUL_PREF_POINTER_MODE_MASK, CUBLASLT_MATMUL_PREF_EPILOGUE_MASK, and CUBLASLT_MATMUL_PREF_SM_COUNT_TARGET from cublasLtMatmulPreferenceAttributes_t. The corresponding parameters are taken directly from cublasLtMatmulDesc_t.
- CUBLASLT_POINTER_MODE_MASK_NO_FILTERING from cublasLtPointerModeMask_t. This mask was only applicable to CUBLASLT_MATMUL_PREF_MATH_MODE_MASK which was removed.

6.2. cuFFT Library

6.2.1. cuFFT: Release 12.1 Update 1

- **Known Issues**
  - cuFFT exhibits a race condition when one thread calls cufftCreate (or cufftDestroy) and another thread calls any API (except cufftCreate or cufftDestroy), and when the total number of plans alive exceeds 1023.
  - cuFFT exhibits a race condition when multiple threads call cufftXtSetGPUs concurrently on different plans.

6.2.2. cuFFT: Release 12.1

- **New Features**
  - Improved performance on Hopper GPUs for hundreds of FFTs of sizes ranging from 14 to 28800. The improved performance spans over 542 cases across single and double precision for FFTs with contiguous data layout.
- **Known Issues**
  - Starting from CUDA 11.8, CUDA Graphs are no longer supported for callback routines that load data in out-of-place mode transforms. An upcoming release will update the cuFFT callback implementation, removing this limitation. cuFFT deprecated callback functionality based on separate compiled device code in cuFFT 11.4.
- **Resolved Issues**
  - cuFFT no longer produces errors with compute-sanitizer at program exit if the CUDA context used at plan creation was destroyed prior to program exit.

6.2.3. cuFFT: Release 12.0 Update 1

- **Resolved Issues**
  - Scratch space requirements for multi-GPU, single-batch, 1D FFTs were reduced.

6.2.4. cuFFT: Release 12.0

- **New Features**
  - PTX JIT kernel compilation allowed the addition of many new accelerated cases for Maxwell, Pascal, Volta and Turing architectures.
- **Known Issues**
  - cuFFT plan generation time increases due to PTX JIT compiling. Refer to Plan Initialization TIme.
- **Resolved Issues**
  - cuFFT plans had an unintentional small memory overhead (of a few kB) per plan. This is resolved.

6.3. cuSPARSE Library

6.3.1. cuSPARSE: Release 12.1 Update 1

- **New Features**
  - Introduced Block Sparse Row (BSR) sparse matrix storage for the Generic APIs with support for SDDMM routine (`cusparseSDDMM`).
  - Introduced Sliced Ellpack (SELL) sparse matrix storage format for the Generic APIs with support for sparse matrix-vector multiplication (`cusparseSpMV`) and triangular solver with a single right-hand side (`cusparseSpSV`).
  - Added a new API call (`cusparseSpSV_updateMatrix`) to update matrix values and/or the matrix diagonal in the sparse triangular solver with a single right-hand side after the analysis step.

6.3.2. cuSPARSE: Release 12.0 Update 1

- **New Features**
  - `cusparseSDDMM()` now supports mixed precision computation.
  - Improved `cusparseSpMM()` alg2 mixed-precision performance on some matrices on NVIDIA Ampere architecture GPUs.
  - Improved `cusparseSpMV()` performance with a new load balancing algorithm.

  - `cusparseSpSV()` and `cusparseSpSM()` now support in-place computation, namely the output and input vectors/matrices have the same memory address.
- **Resolved Issues**
  - `cusparseSpSM()` could produce wrong results if the leading dimension (ld) of the RHS matrix is greater than the number of columns/rows.

6.3.3. cuSPARSE: Release 12.0

- **New Features**
  - JIT LTO functionalities (`cusparseSpMMOp()`) switched from driver to nvJitLto library. Starting from CUDA 12.0 the user needs to link to `libnvJitLto.so`, see cuSPARSE documentation. JIT LTO performance has also been improved for `cusparseSpMMOpPlan()`.
  - Introduced const descriptors for the Generic APIs, for example, `cusparseConstSpVecGet()`. Now the Generic APIs interface clearly declares when a descriptor and its data are modified by the cuSPARSE functions.
  - Added two new algorithms to `cusparseSpGEMM()` with lower memory utilization. The first algorithm computes a strict bound on the number of intermediate product, while the second one allows partitioning the computation in chunks.
  - Added `int8_t` support to `cusparseGather()`, `cusparseScatter()`, and `cusparseCsr2cscEx2()`.
  - Improved `cusparseSpSV()` performance for both the analysis and the solving phases.
  - Improved `cusparseSpSM()` performance for both the analysis and the solving phases.
  - Improved `cusparseSDDMM()` performance and added support for batch computation.
  - Improved `cusparseCsr2cscEx2()` performance.
- **Resolved Issues**
  - `cusparseSpSV()` and `cusparseSpSM()` could produce wrong results.
  - `cusparseDnMatGetStridedBatch()` did not accept `batchStride == 0`.
- **Deprecations**
  - Removed deprecated CUDA 11.x APIs, enumerators, and descriptors.

6.4. Math Library

6.4.1. CUDA Math: Release 12.1

- **New Features**
  - Performance and accuracy improvements in `atanf`, `acosf`, `asinf`, `sinpif`, `cospif`, `powf`, `erff`, and `tgammaf`.

6.4.2. CUDA Math: Release 12.0

- **New Features**
  - Introduced new integer/fp16/bf16 CUDA Math APIs to help expose performance benefits of new DPX instructions. Refer to https://docs.nvidia.com/cuda/cuda-math-api/index.html.

  Known Issues
  - Double precision inputs that cause the double precision division algorithm in the default 'round to nearest even mode' produce spurious overflow: an infinite result is delivered where `DBL_MAX 0x7FEF_FFFF_FFFF_FFFF` is expected. Affected CUDA Math APIs: `__ddiv_rn()`. Affected CUDA language operation: double precision / operation in the device code.
- **Deprecations**
  - All previously deprecated undocumented APIs are removed from CUDA 12.0.

6.5. NVIDIA Performance Primitives (NPP)

6.5.1. NPP: Release 12.0

- **Deprecations**
  - Deprecating non-CTX API support from next release.
- **Resolved Issues**
  - A performance issue with the NPP `ResizeSqrPixel` API is now fixed and shows improved performance.

6.6. nvJPEG Library

6.6.1. nvJPEG: Release 12.0

- **New Features**
  - Immproved the GPU Memory optimisation for the nvJPEG codec.
- **Resolved Issues**
  - An issue that causes runtime failures when `nvJPEGDecMultipleInstances` was tested with a large number of threads is resolved.
  - An issue with CMYK four component color conversion is now resolved.
- **Known Issues**
  - Backend `NVJPEG_BACKEND_GPU_HYBRID` - Unable to handle bistreams with extra scans lengths.
- **Deprecations**

- The reuse of Huffman table in Encoder (`nvjpegEncoderParamsCopyHuffmanTables`).

Chapter 7. Notices

7.1. Notice

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