Standardization of the Batched BLAS

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Contributions from many colleagues:
icl.utk.edu/bblas/

A Brief BLAS History

- 1970s Level 1 BLAS developed, aimed at vector operations. Made the `AXPY` operation famous!
- 1979 Level 1 BLAS published in ToMS. The LINPACK Users' Guide published
- 1988 Level 2 BLAS published in ToMS. Aimed at matrix-vector operations
- 1990 The Level 3 BLAS published in ToMS. Aimed at matrix-matrix operations
- 1992 LAPACK released on Gene Golub's 15th birthday (February 29th)

The BLAS and LAPACK are still extensively used.

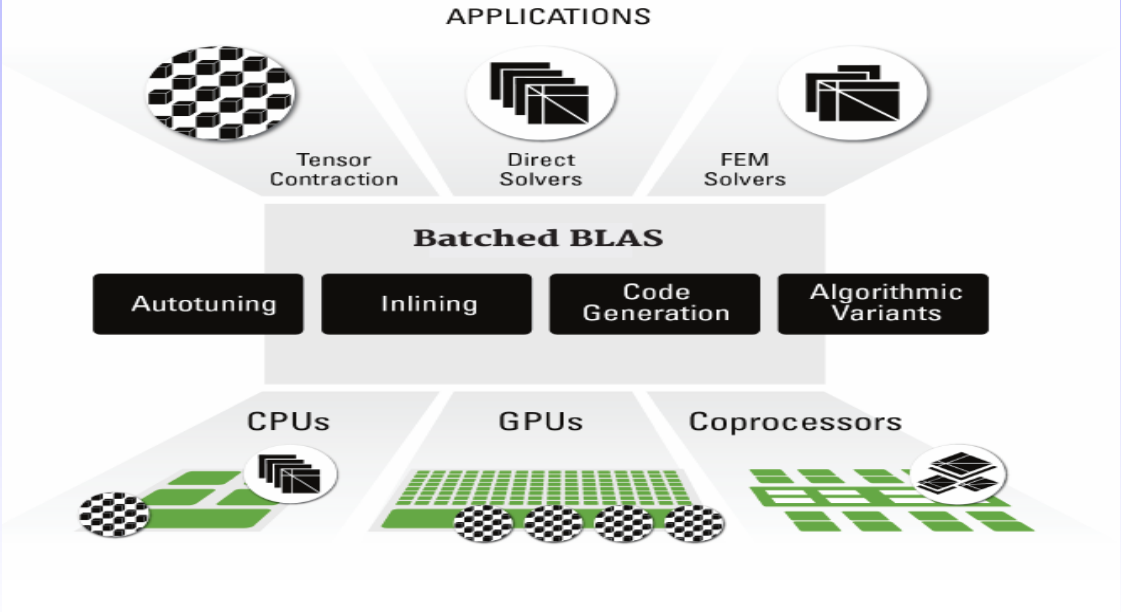
What Are the Batched BLAS (BBLAS)?

A BBLAS is intended to independently perform a large number of a specific BLAS operation. For example

$$C_i \leftarrow \alpha_i A_i B_i + \beta_i C_i, \; i = 1, 2, \ldots \ell,$$

where A_i, B_i and C_i are small matrices.

Many of the BLAS will have a corresponding BBLAS.


APPLICATIONS
Tensor Contraction
Direct Solvers
FEM Solvers
Batched BLAS
Autotuning
Inlining
Code Generation
Algorithmic Variants
CPUs
GPUs
Coprocessors

Specification

- Functionality (e.g. $C_i \leftarrow \alpha_i \mathrm{op}(A_i)\mathrm{op}(B_i) + \beta_i C_i$, where $\mathrm{op}(X)$ is X or X^T or X^H)
- Description of routine interface (API)
- Numerical stability

As with the BLAS.

Community Involvement

- For the current proposals there have been two workshops, in 2016 and 2017. The workshop reports can be found under: eprints.ma.man.ac.uk by searching for 2494 and 2543
- There were BoF sessions at SC17, ISC18 and SC18
- There was a two part minisyposium on the BBLAS and a presentation as part of an NLAFET minisymposium at SIAM PP18
- This two part BBLAS minisymposium here at SIAM CSE19.
- A report, D7.6 (Batched BLAS Specification), can be found at: www.nlafet.eu and under 'PAPERS' at: icl.utk.edu/bblas

Who Supports the BBLAS?

- Intel (MKL)
- Nvidia (cuBLAS)
- MATLAB (pagefun)
- MAGMA
- Kokkos
- Eigen
- ARM (when there is a standard)
- ...

The Proposal

- The matrices are gathered into same sized groups
- Unlike the BLAS, an `info` argument is included and is input/output
- A batch of matrices, for example the A_i, is passed in a single array, for example $A = (A_1 A_2 \ldots A_k)$
- The BLAS name is appended by `_batch`
- The principal language is C (it was Fortran for the BLAS)

A number of other proposals, such as a compact (interleaved) format for the arrays, were considered, but consensus led to the current standard.

Groups

The groups are determined by the integer argument `group_count` and the array of integers `group_sizes` for which the total number of matrices, `batch_count`, is given as

$$\texttt{batch\_count} = \sum_{i=0}^{\texttt{group\_count}-1} \texttt{group\_sizes}(i).$$

(In C style.)

Group Based API

The interface for batched dgemm, for example, looks like:

```
cblas_dgemm_batch( group_count, *group_sizes,
                   layout,
                   *transA, *transB, *m, *n, *k,
                   *alpha, **arrayA, *ldA,
                   **arrayB, *ldB,
                   *beta, **arrayC, *ldC,
                   *info )
```

Info

Error handling is determined by the integer array `info`. On entry `info(0)` should have one of the following values:

BblasErrorsReportAll All errors will be reported on output. Length of the array should be at least `batch_count`

BblasErrorsReportGroup A single error from each group will be reported. Length of the array should be at least `group_count+1`

BblasErrorsReportAny Occurrence of an error will be reported by a single integer value. Length of the array should be at least 1

BblasErrorsReportNone No error will be reported on output. Length of the array should be at least 1

In the BLAS errors were managed by the routine XERBLAS.

Half and Quad Precision

We are adding half and quad precision to the specification. Half precision is important for many of the applications.

Format	Significand	Exponent	Approx. xmax
Half	11 bits	5 bits	6.55×10^4
Single	24 bits	8 bits	3.4×10^{38}
Double	53 bits	11 bits	1.8×10^{308}
Quad	113 bits	15 bits	1.2×10^{4932}

Table: IEEE Arithmetic Formats

We hope that BLAS implementers will also follow suit.

Half Precision

Because of the restricted range, half precision requires care. See for example Higham, Pranesh and Zounon, 2018. See also the first talk at BBLAS part II, proposing a next generation BLAS. (Includes half, quad and mixed precision.)

We don't propose that the BBLAS scale, but rather that it is done at a higher level.

Publication Process

- *De Facto* standard
- Aim to publish in ACM ToMS (as with the BLAS)
- Test software and reference implementation (also described in ToMS)
- The reference (or model) implementation is not intended to be efficient

The current reference software is available at: `github.com/NLAFET/BBLAS`

NLAFET / **BBLAS**

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Reference implementation of the Batched BLAS routines (Group API).

116 commits | **1** branch | **0** releases | **2** contributors

Branch: **master** | New pull request | Find file | Clone or download

SrikaraPranesh Small changes to README — Latest commit 57b006d on 27 Oct 2018

compute	Indentations in compute	4 months ago
control	add info parameter to command line arguments	4 months ago
core	minot modification of comments in core	4 months ago
docs/doxygen	add docs	4 months ago
include	working zsyrk tester	4 months ago
test	Small changes in README	4 months ago
tools	rm tools/subs.pyc	4 months ago
Makefile	clean bblas_types.h, add control/constants.c, rm include/auxiliary.h	4 months ago
README.md	Small changes to README	4 months ago
make.inc	correction of bugs in zhemm	4 months ago

README.md

Batched Basic Linear Algebra Subroutines

University of Manchester (UK)

University of Tennessee (US)

Download BBLAS Software

Batched LAPACK

For the future, we can expect the development of batched LAPACK routines.

Indeed, the MAGMA package, aimed at heterogeneous architectures, is an example that has already implemented some batched LAPACK routines, particularly for the solution of $Ax = b$.

See: icl.cs.utk.edu/magma and the next talk in this session!