A Proposed Modification to the Batch BLAS Interface

Ahmad Abdelfattah
with Azzam Haidar and Stan Tomov

Workshop on Batched, Reproducible, and Reduced Precision BLAS

Friday, February 24th, 2017

ICL INNOVATIVE COMPUTING LABORATORY
THE UNIVERSITY OF TENNESSEE KNOXVILLE

Outline

Outline

What this talk is all about

- Few modifications to the batch BLAS interface
- Based on practical development experience (batched LAPACK)
- The modification is a generalization over the existing interface
  - Both can exist side-by-side
- While the work originally targeted GPUs, most of it is generic, and applies to other architectures

Outline

Motivation

This is a sample MAGMA interface

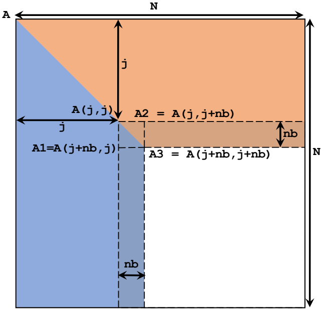
```
void magmablas_dgemm_vbatched(
     enum transA, enum transB,
     int* m, int* n, int* k,
     double alpha, double ** Aarray, int* lda,
                   double ** Barray, int* ldb,
     double beta,  double ** Carray, int* ldc,
     int batchCount, magma_queue_t queue );
```

What are the issues?

- Most of the time, we are dealing with submatrices
- Consistent manipulation of pointer and integer arrays
- In the case of GPUs, manipulations = kernels
  - Potential overhead
  - Bad code readability
  - Challenging to write efficient recursive functions

A non-batched example

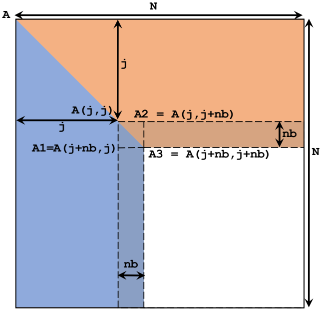
Trailing matrix update of an LU factorization (one matrix)




```
#define dA(i,j)     (dA[ (j) * lda + (i)])
/* some code */
magmablas_dgemm( MagmaNoTrans, MagmaNoTrans,
                 N-(j+nb), N-(j+nb), nb,
                 NEG_ONE, dA(j+nb, j   ), lda,
                          dA(j   , j+nb), lda,
                 ONE    , dA(j+nb, j+nb), lda, queue );
```

Now consider a batched example (fixed size)

We must preprocess arrays before the kernel call

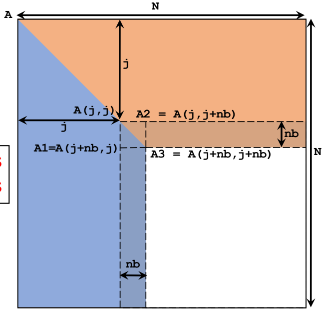



```
/* some code */
magma_displace_pointers(dA1_array, dA_array,  lda, j+nb, j   , batchCount, queue);
magma_displace_pointers(dA2_array, dA_array,  lda, j   , j+nb, batchCount, queue);
magma_displace_pointers(dA3_array, dA_array,  lda, j+nb, j+nb, batchCount, queue);
magmablas_dgemm_batched( MagmaNoTrans, MagmaNoTrans,
                         N-(j+nb), N-(j+nb), nb,
                         NEG_ONE, dA1_array, lda,
                                  dA2_array, lda,
                         ONE    , dA3_array, lda, batchCount, queue );
```

Now consider a batched example (fixed size)

We must preprocess arrays before the kernel call

Fixed size: we need kernels to manipulate pointer arrays

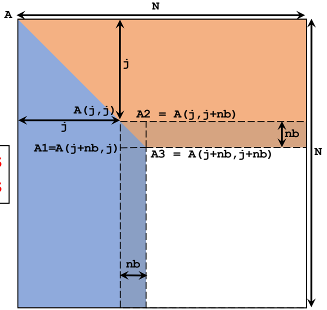



```
/* some code */
magma_displace_pointers(dA1_array, dA_array,  lda, j+nb, j   , batchCount, queue);
magma_displace_pointers(dA2_array, dA_array,  lda, j   , j+nb, batchCount, queue);
magma_displace_pointers(dA3_array, dA_array,  lda, j+nb, j+nb, batchCount, queue);
magmablas_dgemm_batched( MagmaNoTrans, MagmaNoTrans,
                         N-(j+nb), N-(j+nb), nb,
                         NEG_ONE, dA1_array, lda,
                                  dA2_array, lda,
                         ONE    , dA3_array, lda, batchCount, queue );
```

Now consider a batched example (fixed size)

We must preprocess arrays before the kernel call

Fixed size: we need kernels to manipulate pointer arrays



Var. size: we also need kernels to manipulate integer arrays

```
/* some code */
magma_displace_pointers(dA1_array, dA_array,  lda, j+nb, j   , batchCount, queue);
magma_displace_pointers(dA2_array, dA_array,  lda, j   , j+nb, batchCount, queue);
magma_displace_pointers(dA3_array, dA_array,  lda, j+nb, j+nb, batchCount, queue);
magmablas_dgemm_batched( MagmaNoTrans, MagmaNoTrans,
                         N-(j+nb), N-(j+nb), nb,
                         NEG_ONE, dA1_array, lda,
                                  dA2_array, lda,
                         ONE    , dA3_array, lda, batchCount, queue );
```

To wrap up

- We need to manipulate pointer and integer arrays (custom kernels)
- This can be done in-place, but:
  - These arrays are inputs (EVEN FOR OUTPUT MATRICES)
  - Multiple displacements of the same array in a single call
- Many allocations are required per routines
  - Problem of asynchronicity rather than overhead
- Recursion is very difficult
  - Allocation/deallocation inside a recursive function!

Outline

Design Goals

- No manipulation of pointer/integer arrays in separate kernels
- Better code readability
- Fully asynchronous routines
  - At least for BLAS
- Full support for recursive functions

What do we propose?

More Informative APIs

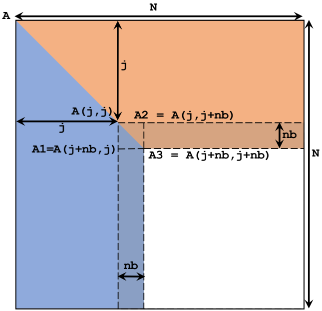
- We are going to expand the interface
- Fixed size routines:
  - `(i, j)` offsets for every pointer array
- Variable size routines
  - `(i, j)` offsets for every pointer array, and
  - a scalar size per integer array

Eventually, batched kernels deduce location/size instead of just reading them

Outline

Fixed size APIs

- Every pointer array is associated with two integers that represent row and column offsets

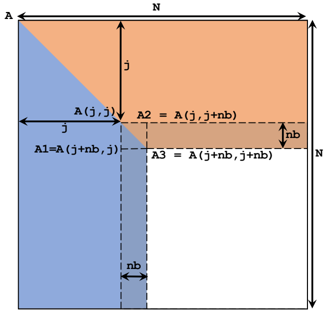



```
/* some code */
magmablas_dgemm_batched( MagmaNoTrans, MagmaNoTrans,
                         N-(j+nb), N-(j+nb), nb,
                         NEG_ONE, dA_array, j+nb, j    , lda,
                                  dA_array, j   , j+nb, lda,
                         ONE    , dA_array, j+nb, j+nb, lda, batchCount, queue );
```

Fixed size APIs

- Every pointer array is associated with two integers that represent row and column offsets

Each sub-kernel computes the correct pointer




```
/* some code */
magmablas_dgemm_batched( MagmaNoTrans, MagmaNoTrans,
                         N-(j+nb), N-(j+nb), nb,
                         NEG_ONE, dA_array, j+nb, j   , lda,
                                  dA_array, j   , j+nb, lda,
                         ONE    , dA_array, j+nb, j+nb, lda, batchCount, queue );
```

Variable size APIs

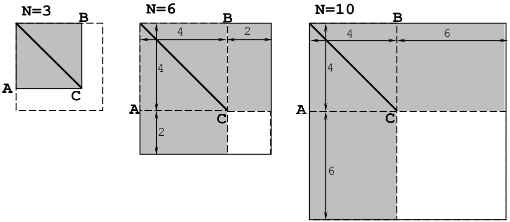
- Every pointer array is associated with two integers that represent row and column offsets
- Integer arrays remain untouched
- We need to specify extra sizes of the operation according to the biggest matrix

```
/* some code */
magmablas_dgemm_vbatched( MagmaNoTrans, MagmaNoTrans,
                          N_array, N_array, N_array,
                          NEG_ONE    , dA_array, j+nb, j   , lda_array,
                                       dA_array, j   , j+nb, lda_array,
                          ONE        , dA_array, j+nb, j+nb, lda_array,
                          Nmax-(j+nb), Nmax-(j+nb), nb,
                          batchCount, queue );
```

- Similarly, every sub-kernel deduces the correct sizes based on the offsets + the extra sizes

Variable size APIs "cont."

LU update (C = C – A×B), 1st iteration, nb=4, N_{max}=10



Configuration of GEMM update: $C_{m \times n} = C_{m \times n} - A_{m \times k} \times B_{k \times n}$

matrix	size	requested (m, n, k)	affordable (m, n, k)	executed (m, n, k)
0	3	(6, 6, 4)	(0, 0, 0)	(0, 0, 0)
1	6	(6, 6, 4)	(2, 2, 6)	(2, 2, 4)
2	10	(6, 6, 4)	(6, 6, 10)	(6, 6, 4)

Recursive Batched Computation

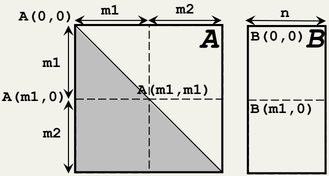
- Example: batched TRSM (fixed size)

```
/* some code */
const int m2 = m / 2;
const int m1 = m - m2;

magmablas_dtrsm_batched( side, uplo, transA, diag,
        m1, n, alpha,
        dA_array, 0, 0, ldda,
        dB_array, 0, 0, lddb,
        batchCount, queue );

magmablas_dgemm_batched( MagmaNoTrans, MagmaNoTrans,
        m2, n, m1,
        neg_one, dA_array, m1, 0, ldda,
                 dB_array, 0 , 0, lddb,
        alpha  , dB_array, m1, 0, lddb,
        batchCount, queue );

magmablas_dtrsm_batched( side, uplo, transA, diag,
        m2, n, c_one,
        dA_array, m1, m1, ldda,
        dB_array, m1, 0 , lddb,
        batchCount, queue );
```



Outline

Conclusion and Future Work

To summarize:

- The current batch BLAS API makes it challenging to develop higher level batched operations
- The new API is longer, but it can look nicer
- The new API is very efficient in recursive function

Future Directions:

- Populate the new API in several MAGMA routines (while keeping the old one)
- Look for feedback/potential improvements

Thank You!