The KAUST SVD (KSVD) is a high performance software framework for computing a dense SVD on distributed-memory manycore systems. The KSVD solver relies on the polar decomposition using the QR Dynamically-Weighted Halley algorithm (QDWH), introduced by Nakatsukasa and Higham (SIAM Journal on Scientific Computing, 2013). The computational challenge resides in the significant amount of extra floating-point operations required by the QDWH-based SVD algorithm, compared to the traditional one-stage bidiagonal SVD. However, the inherent high level of concurrency associated with Level 3 BLAS compute-bound kernels ultimately compensates the arithmetic complexity overhead and makes KSVD a competitive SVD solver on large-scale supercomputers.

### The Polar Decomposition
- \( A = U H \), where \( U \) is an orthogonal Matrix, and \( H \) is positive semidefinite matrix

### QDWH Algorithm
- Backward stable algorithm for computing the QDWH-based SVD
- Based on conventional computational kernels, i.e., Cholesky/QR factorizations (≤ 6 iterations for double precision) and GEMM
- The total flop count for QDWH depends on the condition number \( \kappa \) of the matrix

### Performance Results

#### Cray XC40 6174 nodes, Intel Haswell 2.3GHz two-sockets 16 cores

#### Cray XC 576 nodes, Intel Xeon Phi Knights Landing (KNL), 1.4GHz 68 cores

#### Current Research
- Chameleon 0.9.1
  - Asynchronous, Task-Based QDWH
  - Dynamic Scheduling
  - Hardware Accelerators
  - Distributed Memory Machines
  - Asynchronous, Task-Based QDWH-SVD
  - QDWH-based Eigensolver
    - [QDWH-EIG]
  - Integration into PLASMA/MAGMA

### Advantages
- Performs extra flops but nice flops
- Relies on compute intensive kernels
- Exposes high concurrency
- Maps well to GPU architectures
- Minimizes data movement
- Weakens resource synchronizations

### KSVD 1.0
- Cray LibSci 17.11.1
- QDWH-based Polar Decomposition
- Singular Value Decomposition
- Double Precision
- Support to ELPA Symmetric Eigensolver
- Support to ScALAPACK D&C and MR² Symmetric Eigensolvers
- ScALAPACK Interface / Native Interface
- ScALAPACK-Compliant Error Handling
- ScALAPACK-Derived Testing Suite
- ScALAPACK-Compliant Accuracy

### State-of-the-Art
- ScaLAPACK-Compliant Accuracy

Download the software at [http://github.com/ecrc/ksvd](http://github.com/ecrc/ksvd)