School of Mathematical and Statistical Sciences
Arizona State University

M E M O R A N D U M

DATE: 1/27/2025

TO: Faculty and Students

FROM: Professor(s) Rosemary Renaut
Chair/Co-Chairs of Abdulmajeed Homied S. Alsubhi
Defense for the PhD in Applied Mathematics
PhD Committee Members Johannes Brust
Malena Espanol
Rodrigo Platte
Sebastien Motsch

DEFENSE ANNOUNCEMENT

Candidate: Abdulmajeed Homied S. Alsubhi

Defense Date: Thursday 2/27/2025

Defense Time: 2:00 PM

Location: WXLR 546

Virtual Meeting Link: https://asu.zoom.us/j/4751300905

Title: Using Single Precision with Enlarged-GKB or RSVD Algorithms to Provide Low Rank Truncated SVDs

Please share this information with colleagues and other students, especially those studying in similar fields. Faculty and students are encouraged to attend. The defending candidate will give a 40-minute talk, after which the committee members will ask questions. There may be time for questions from those in attendance. But, guests are primarily invited to attend as observers and will be excused when the committee begins its deliberations or if the committee wishes to question the candidate privately.

ABSTRACT

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ABSTRACT

The singular value decomposition technique is useful for matrix factorization and dimensionality reduction but becomes computationally expensive for large matrices. To address this challenge, the **enlarged** Golub Kahan Bidiagonalization algorithm is studied, which proceeds by enlarging the Krylov subspace beyond a given rank for the desired approximation. This method is contrasted with the truncated singular value decomposition and randomized singular value decompositions using the same number of terms. A single precision is used to extend the scale of the problems that can be considered. For large-scale, non-separable image deblurring problems, the sys- tem matrix A is approximated using a Kronecker product approximation obtained via the aforementioned approximate truncated singular value decompositions for the reordered matrix of A. An automatic stopping test is proposed to provide a suitable rank for this approximation. The solution of the ℓ_1 regularized image deblurring problem is considered using isotropic and anisotropic regularization implemented with the split Bregman algorithm in double precision. Several numerical experiments demonstrate the effectiveness of the presented approaches, showing that the major costs are associated with determining the Kronecker product approximation, rather than with the cost of the regularization algorithm. Moreover, the enlarged Golub Kahan Bidiagonalization algorithm competes favorably with the randomized singular value decomposition for estimating the approximate singular value decomposition.

The hybrid projection framework, here is based on the enlarged Golub Kahan Bidiagonalization or the randomized singular value decomposition, is applied to the Tikhonov problem in standard form. In this approach, the approximate truncated singular value decomposition and the regularization steps are computed entirely using single precision. The truncation parameter is determined to minimize the generalized cross-validation function based on a predetermined rank related to the ma-

trix dimension. Numerical experiments, including image deblurring and tomography, demonstrate the effectiveness of these algorithms in producing comparable regularized solutions to those obtained in double precision.

Furthermore, the inversion of three-dimensional problems arising from geophysics is considered using iteratively reweighted least squares based on the standard Tikhonov problem. Numerical results for different noise levels demonstrate the effectiveness of using single precision to generate the system matrices for the geophysics problem and for conducting the inversion.