**Abstract:** A contour integral based method (SSEig) has recently been developed for computing internal eigenvalues of large-scale generalized eigenvalue problems. However, its performance has not been fully studied. In this poster, we present a comparative study of SSEig with Arnoldi/Lanczos based methods (PARPACK/TRLan). The test problems were generated from the real symmetric matrices arising from accelerator cavity design simulations. We study both the numerical and the parallel performance of these methods.

**Numerical Experiments**

The experiments were conducted on NERSC Franklin (Cray XT4). Each node contains quad-core Opteron 2.3 GHz processor with 8 GBytes of memory. For the invert operation, SuperLU_DIST was used.

**Example 1.** We study the performance of PARPACK and TRLan to computenev eigenvalues (Table 1 and 2). The eigenvalues closest to a shift c=700 were computed with the projection space of ncv=3nev. "ops" is the number of the invert operations, and "time" is in seconds. The experiments were conducted using eight cores (one core per node). "min" and "max" are the maximum and minimum relative residuals of nev eigenpairs.

**Example 2.** We now study the performance of SSEig (Table 3). For these experiments, we use N quadrature nodes to find nev eigenvalues. The block sizes (the number of columns of V) is \(L=6\). The contour is created with \((ρj)(700, 500)\). In the table, "ops" is the number of the invert operations. The experiments were conducted using eight cores (one core per node).

**Conclusions and Future Works**

We studied the performance of parallel eigenvalue solvers. The parallelization strategies of PARPACK/TRLan and SSEig are quite different. PARPACK/TRLan: The scalability strictly depends on a linear solver used in spectral transformations, and the scalability depends on a linear solver with \(p\) processes in which \(Np\) processes are employed. It provides a potential breakthrough to achieve good performance with large number of processors. Our future work is a comparative study for solving large-scale problems.

One of our future works is to apply a nonlinear variant of SSEig to the nonlinear eigenvalue problem derived from accelerator cavity design simulations. We show a preliminary result applied for the test matrix valued function

\[ \mathbf{T}(\lambda) = \mathbf{K} - \mathbf{\lambda} \mathbf{A} + i / \mathbf{\lambda} \mathbf{X} \mathbf{\lambda} - \mathbf{\lambda}^2 \mathbf{X} - \mathbf{\lambda}^3 \mathbf{X} \]

where \(\mathbf{K}, \mathbf{A}, \mathbf{X}\) are real symmetric of dimension 1,100,242, \(\mathbf{\lambda}\) is a 640, and \(i\) is the imaginary unit. The calculation was done on T2K-Tsukuba system (quad-core Opteron 2.3GHz x 4 sockets per node). PARDISO in MKL was used as a linear solver.

**Parallelization Strategy**

The following figures show parallel strategies of PARPACK, TRLan and SSEig when a sparse direct solver is used to solve systems of linear equations. When \(p\) processors are assigned to solve a system of linear equations, SSEig can solve \(N\) systems of linear equations simultaneously.

**References**


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