

Sparse Matrix Library: Input and Output Report

Xiaobai Jiang, Yuwei An, Shuting Zhang

Overview

This report documents the inputs and outputs of our sparse matrix library, which supports matrix generation, decomposition (LU, QR, Cholesky), and eigenvalue solving (Power, Inverse, Lanczos, Arnoldi, QR iterations). We include both console outputs and explanation of results from `test.cpp` and `test_svd.cpp`. The outputs for Matrix Generation, EigenSolver and Matrix Decomposition are by running the "make test" on `test.cpp` and the output from SVD is by running the "make test_svd" on `test_svd.cpp`.

1. Matrix Generation

Random Sparse Matrix

```
[Generated Random Sparse Matrix]
(0, 2) = -0.0144228
(1, 4) = 0.674721
...
```

Symmetric Positive Definite (SPD) Matrix

Used as input for eigenvalue and decomposition algorithms.

2. EigenSolver Outputs

Generated from `test.cpp` with SPD matrix of size 50, iteration limit = 50. The number of eigenvalues Lanczos Iteration and Arnoldi Iteration solved is set to be 10.

Power Iteration

```
[Testing Power Iteration]
Estimated dominant eigenvalue (Power Iteration): 792.356
Time taken: 0 ms
```

Inverse Iteration

```
[Testing Inverse Iteration]
Estimated smallest eigenvalue (Inverse Iteration): 5.25056e-08
Time taken: 145 ms
```

QR Iteration

```
[Testing QR Iteration]
Time taken: 19478 ms
[QR eigenvalues (first 10)]
792.356 12.8577 11.9656 10.7768 9.66794 ...
```

Lanczos Iteration

```
[Testing Lanczos Iteration]
Time taken: 13 ms
[Lanczos eigenvalues (first 10)]
792.356 792.355 12.778 11.4522 9.91066 ...
```

Arnoldi Iteration

```
[Testing Arnoldi Iteration]
Time taken: 13 ms
[Arnoldi eigenvalues (first 10)]
792.356 12.8503 11.6539 10.3237 8.81115 ...
```

3. Matrix Decomposition Outputs

LU Decomposition

```
[L Matrix]
...
[U Matrix]
...
Frobenius Norm of Difference (L * U - A): 2.23217e-10
Time: 3290800 ns
```

QR Decomposition

```
[Q Matrix]
...
[R Matrix]
...
Frobenius Norm of Difference (Q * R - A): 1.02123e-9
Time: 4781300 ns
```

Cholesky Decomposition

```
[L Matrix]
...
Frobenius Norm of Difference (L * LT - A): 8.10232e-11
Time: 2119000 ns
```

4. SVD Output

test_svd.cpp

```
Estimated Largest singular value: 5.4872  
Largest singular value from LAPACK: 5.4921
```

5. Conclusion

All decompositions were validated using Frobenius norm and execution time. The library achieves both functional correctness and performance for sparse matrix computations.