cond

Condition number for inversion

Syntax

```
C = cond(A)
C = cond(A,p)
```

Description

`C = cond(A)` returns the 2-norm condition number for inversion, equal to the ratio of the largest singular value of `A` to the smallest. example

`C = cond(A,p)` returns the `p`-norm condition number, where `p` can be `1`, `2`, `Inf`, or `'fro'`. example

Examples

collapse all

Condition Number of Matrix

Calculate the condition number of a matrix and examine the sensitivity to the inverse calculation.

Create a 2-by-2 matrix.

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```
A = [4.1 2.8;
     9.7 6.6];
```

Calculate the 2-norm condition number of `A`.

```
C = cond(A)
```

```
C = 1.6230e+03
```

Since the condition number of `A` is much larger than 1, the matrix is sensitive to the inverse calculation. Calculate the inverse of `A`, and then make a small change in the second row of `A` and calculate the inverse again.

```
invA = inv(A)
```

```
invA = 2×2

  -66.0000   28.0000
   97.0000  -41.0000
```

```
A2 = [4.1    2.8;
      9.671  6.608]
```

```
A2 = 2×2

    4.1000    2.8000
    9.6710    6.6080
```

```
invA2 = inv(A2)
```

```
invA2 = 2×2

  472.0000 -200.0000
 -690.7857  292.8571
```

The results indicate that making a small change in A can completely change the result of the inverse calculation.

1-Norm Condition Number

Calculate the 1-norm condition number of a matrix.

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Create a 3-by-3 matrix.

```
A = [1 0 -2;
     3 4  6;
    -1 5  7];
```

Calculate the 1-norm condition number of A. The value of the 1-norm condition number for an *m*-by-*n* matrix is

$$\kappa_1(A) = ||A||_1 \ ||A^{-1}||_1,$$

where the 1-norm is the maximum absolute column sum of the matrix given by

$$||A||_1 = \max_{1 \le j \le n} \sum_{i=1}^{m} |a_{ij}|.$$

```
C = cond(A,1)
```

```
C = 18.0000
```

For this matrix the condition number is not too large, so the matrix is not particularly sensitive to the inverse calculation.

Input Arguments

collapse all

A — Input matrix
matrix

Input matrix. A can be either square or rectangular in size.

Data Types: `single` | `double`
Complex Number Support: Yes

p — Norm type
2 (default) | 1 | `'fro'` | `Inf`

Norm type, specified as one of the values shown in this table. `cond` computes the condition number using `norm(A,p) * norm(inv(A),p)` for values of `p` other than 2. See the `norm` page for additional information about these norm types.

Value of p	Norm Type
`1`	1-norm condition number
`2`	2-norm condition number
`Inf`	Infinity norm condition number
`'fro'`	Frobenius norm condition number

Example: `cond(A,1)` calculates the 1-norm condition number.

Output Arguments

collapse all

`C` — Condition number
scalar

Condition number, returned as a scalar. Values of `C` near 1 indicate a well-conditioned matrix, and large values of `C` indicate an ill-conditioned matrix. Singular matrices have a condition number of `Inf`.

More About

collapse all

Condition Number for Inversion

A *condition number* for a matrix and computational task measures how sensitive the answer is to changes in the input data and roundoff errors in the solution process.

The *condition number for inversion* of a matrix measures the sensitivity of the solution of a system of linear equations to errors in the data. It gives an indication of the accuracy of the results from matrix inversion and the linear equation solution. For example, the 2-norm condition number of a square matrix is

$$\kappa(A) = \|A\|\|A^{-1}\| .$$

In this context, a large condition number indicates that a small change in the coefficient matrix `A` can lead to larger changes in the output `b` in the linear equations $Ax = b$ and $xA = b$. The extreme case is when `A` is so poorly conditioned that it is singular (an infinite condition number), in which case it has no inverse and the linear equation has no unique solution.

Tips

- `rcond` is a more efficient, but less reliable, method of estimating the condition of a matrix compared to `cond`.

Algorithms

The algorithm for `cond` has three pieces:

- If `p = 2`, then `cond` uses the singular value decomposition provided by `svd` to find the ratio of the largest and smallest singular values.
- If `p = 1`, `Inf`, or `'fro'`, then `cond` calculates the condition number using the appropriate norm of the input matrix and its inverse with `norm(A,p) * norm(inv(A),p)`.

- If the input matrix is sparse, then `cond` ignores any specified `p` value and calls `condest`.

Extended Capabilities

> **C/C++ Code Generation**
Generate C and C++ code using MATLAB® Coder™.

> **GPU Arrays**
Accelerate code by running on a graphics processing unit (GPU) using Parallel Computing Toolbox™.

> **Distributed Arrays**
Partition large arrays across the combined memory of your cluster using Parallel Computing Toolbox™.

See Also

`condeig` | `condest` | `norm` | `normest` | `rank` | `rcond` | `svd`

External Websites

Cleve's Corner: What is the Condition Number of a Matrix?

Introduced before R2006a