

matexpsym() — Exponentiation and logarithms of symmetric matrices

Description
Diagnostics

Syntax
Also see

Remarks and examples

Conformability

Description

`matexpsym(A)` returns the matrix exponential of the symmetric (Hermitian) matrix A .

`matlogsym(A)` returns the matrix natural logarithm of the symmetric (Hermitian) matrix A .

`_matexpsym(A)` and `_matlogsym(A)` do the same thing as `matexpsym()` and `matlogsym()`, but instead of returning the result, they store the result in A .

Syntax

numeric matrix `matexpsym(numeric matrix A)`

numeric matrix `matlogsym(numeric matrix A)`

void `_matexpsym(numeric matrix A)`

void `_matlogsym(numeric matrix A)`

Remarks and examples

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Do not confuse `matexpsym(A)` with `exp(A)`, nor `matlogsym(A)` with `log(A)`.

`matexpsym(2*matlogsym(A))` produces the same result as $A*A$. `exp()` and `log()` return elementwise results.

Exponentiated results and logarithms are obtained by extracting the eigenvectors and eigenvalues of A , performing the operation on the eigenvalues, and then rebuilding the matrix. That is, first X and L are found such that

$$AX = X * \text{diag}(L) \tag{1}$$

For symmetric (Hermitian) matrix A , X is orthogonal, meaning $X'X = XX' = I$. Thus

$$A = X * \text{diag}(L) * X' \tag{2}$$

`matexpsym(A)` is then defined

$$A = X * \text{diag}(\exp(L)) * X' \tag{3}$$

and `matlogsym(A)` is defined

$$A = X * \text{diag}(\log(L)) * X' \tag{4}$$

(1) is obtained via `symeigensystem()`; see [M-5] `eigensystem()`.

Conformability

`matexpsym(A)`, `matlogsym(A)`:

A: $n \times n$

result: $n \times n$

`_matexpsym(A)`, `_matlogsym(A)`:

input:

A: $n \times n$

output:

A: $n \times n$

Diagnostics

`matexpsym(A)`, `matlogsym(A)`, `_matexpsym(A)`, and `_matlogsym(A)` return missing results if *A* contains missing values.

Also:

1. These functions do not check that *A* is symmetric or Hermitian. If *A* is a real matrix, only the lower triangle, including the diagonal, is used. If *A* is a complex matrix, only the lower triangle and the real parts of the diagonal elements are used.
2. These functions return a matrix of the same storage type as *A*.

For `symatlog(A)`, this means that if *A* is real and the result cannot be expressed as a real, a matrix of missing values is returned. If you want the generalized solution, code `matlogsym(C(A))`. This is the same rule as with scalars: `log(-1)` evaluates to missing, but `log(C(-1))` is `3.14159265i`.

3. These functions are guaranteed to return a matrix that is numerically symmetric, Hermitian, or `symmetriconly` if theory states that the matrix should be symmetric, Hermitian, or `symmetriconly`. See [M-5] `matpowersym()` for a discussion of this issue.

For the functions here, real function `exp(x)` is defined for all real values of *x* (ignoring overflow), and thus the matrix returned by `matexpsym()` will be symmetric (Hermitian).

The same is not true for `matlogsym()`. `log(x)` is not defined for $x = 0$, so if any of the eigenvalues of *A* are 0 or very small, a matrix of missing values will result. Also, `log(x)` is complex for $x < 0$, and thus if any of the eigenvalues are negative, the resulting matrix will be (1) missing if *A* is real stored as real, (2) `symmetriconly` if *A* contains reals stored as complex, and (3) general if *A* is complex.

Also see

[M-5] `matpowersym()` — Powers of a symmetric matrix

[M-5] `eigensystem()` — Eigenvectors and eigenvalues

[M-4] `matrix` — Matrix functions