generate a positive semi-definite matrices??

Subject: generate a positive semi-definite matrices??
From: VijaKhara
Date: 10 Feb, 2008 02:50:10
Message: 1 of 12

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Hi all

I need to generate a 3x3 positive semi-definite matrix but I don't know what MATLAB function can do this?
Or is there any method to generate without try & check method?

Also, do you know what MATLAB function can be used to check if a matrix is a positive semi-definite matrix?

Thank you

Subject: generate a positive semi-

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definite matrices??
From: James Tursa
Date: 10 Feb, 2008 03:17:33
Message: 2 of 12

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On Sat, 9 Feb 2008 18:50:10 -0800 (PST), VijaKhara
<VijaKhara@gmail.com> wrote:

>Hi all
>
>
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>know what MATLAB function can do this?
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>Also, do you know what MATLAB function can be used to check if a
>matrix is a positive semi-definite matrix?
>
>Thank you

One way to generate a random positive semi-definite 3x3 matrix:

```
a = rand(3,3)
ata = a'*a
```

To check, use the eig function to see that all of the eigenvalues are non-negative

```
eig(ata)
```

James Tursa

Subject: generate a positive semi-definite matrices??
From: Roger Stafford
Date: 10 Feb, 2008 03:48:01
Message: 3 of 12

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VijaKhara <VijaKhara@gmail.com> wrote in message <b082bc0e-5d7a-4bcf-ab79-478ad6a820f9@e4g2000hsg.googlegroups.com>...
> Hi all
>
>
> I need to generate a 3x3 positive semi-definite matrix but I don't
> know what MATLAB function can do this?
> Or is there any method to generate without try & check method?
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> matrix is a positive semi-definite matrix?
>
> Thank you

----

1. Generate a random 3 x 3 unitary matrix and a random set of three non-negative eigenvalues.

```
A = randn(3);
[U,ignore] = eig((A+A')/2); % (Don't really have to divide by 2)
M = U*diag(abs(randn(3,1)))*U';
```

Then M is a randomly determined positive semi-definite matrix.

2. Check that M is positive semi-definite:

all(diag(eig((M+M')/2))) >= 0

If this is true, then M is positive semi-definite

Roger Stafford

Subject: generate a positive semi-definite matrices??
From: James Tursa
Date: 10 Feb, 2008 08:38:01
Message: 4 of 12

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James Tursa <aclassyguywithaknotac@hotmail.com> wrote in message <0rqsq3tqr22j3e1h3emodegqmra5bd76rt@4ax.com>...
> On Sat, 9 Feb 2008 18:50:10 -0800 (PST), VijaKhara
> <VijaKhara@gmail.com> wrote:
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> One way to generate a random positive semi-definite 3x3 matrix:
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> a = rand(3,3)
> ata = a'*a
>
> To check, use the eig function to see that all of the eigenvalues are
> non-negative
>
> eig(ata)
>
> James Tursa

Clarify: "ata" is the positive semi-definite matrix, not "a".

Subject: generate a positive semi-definite matrices??
From: Roger Stafford
Date: 10 Feb, 2008 09:17:02
Message: 5 of 12

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"Roger Stafford" <ellieandrogerxyzzy@mindspring.com.invalid> wrote in message <fols5h$e71$1@fred.mathworks.com>...
> ....
> 2. Check that M is positive semi-definite:
>
> all(diag(eig((M+M')/2))) >= 0
>
> If this is true, then M is positive semi-definite

In the check for M to be positive semi-definite I should have written:

all(eig((M+M')/2)) >= 0

I forgot that eig with only one output produces a vector result, not a square array, and the diag operation should not be used.

Second observation: There seem to be two definitions of a semi-definite matrix floating around. One, as for example in Wikipedia, insists that it both be Hermitian and have non-negative eigenvalues. The other definition, as for example in MathWorld and which I have used here, requires only that its Hermitian part, (M+M')/2, have non-negative eigenvalues.

Roger Stafford

Subject: generate a positive semi-definite matrices??
From: James Tursa
Date: 10 Feb, 2008 19:52:17
Message: 6 of 12

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On Sun, 10 Feb 2008 09:17:02 +0000 (UTC), "Roger Stafford"
<ellieandrogerxyzzy@mindspring.com.invalid> wrote:

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>be Hermitian and have non-negative eigenvalues. The other definition, as
for
>example in MathWorld and which I have used here, requires only that its
>Hermitian part, (M+M')/2, have non-negative eigenvalues.
>
>Roger Stafford
>

Where, exactly, are you getting these definitions from? Can you post some web links? The Hermitian restriction does not agree with my understanding at all. For a matrix M to be positive semi-definite, it simply has to satisfy this (which I am sure you already know but I repeat for others):

x' * M * x >= 0 for all non-zero vectors x

where x' is the complex conjugate transpose operator.

And testing the sign of all of the eigenvalues of M is a necessary and sufficient test for this. I am not sure what the M + M' calculation in your post (from other links) has to do with this. For example, see this wiki link which agrees with my understanding:

http://en.wikipedia.org/wiki/Positive-definite_matrix

Here is an example of a random matrix I generated in MATLAB that is not Hermitian but is positive semi-definite:

```
0.95012928514718 0.48598246870930 0.45646766516834
0.23113851357429 0.89129896614890 0.01850364324822
0.60684258354179 0.76209683302739 0.82140716429525
```

A Hermitian matrix (i.e., where isequal(M,M') is true) *will* be positive semi-definite (an easy thing to prove), but it is not a necessary condition for positive semi-definiteness. Perhaps this is where the confusion is?

James Tursa

Subject: generate a positive semi-definite matrices??
From: Roger Stafford
Date: 10 Feb, 2008 21:55:03
Message: 7 of 12

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James Tursa <aclassyguywithaknotac@hotmail.com> wrote in message
<3dkuq3ls0516g4inapn6hvll7sac7k44np@4ax.com>...
> On Sun, 10 Feb 2008 09:17:02 +0000 (UTC), "Roger Stafford"
> <ellieandrogerxyzzy@mindspring.com.invalid> wrote:
> > Second observation: There seem to be two definitions of a semi-definite
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> A Hermitian matrix (i.e., where isequal(M,M') is true) *will* be
> positive semi-definite (an easy thing to prove), but it is not a
> necessary condition for positive semi-definiteness. Perhaps this is
> where the confusion is?
>
> James Tursa

I dug up a few web sites pertinent to this matter, James. You'll note that the first one is the site you mentioned. In its first paragraph, which I quote below, it appears to restrict positive definite matrices to those that are Hermitian. The same is true of the MathWorld site for semi-definite matrices, though elsewhere MathWorld states it differently. The matter is explained in greater depth in the third site below which discusses non-Hermitian matrices in one of its paragraphs. As it states in its concluding remark in this paragraph, "There is no agreement in the literature on the proper definition of positive-definite for non-Hermitian matrices." There are also some very similar remarks to this last in your referenced Wikipedia site.

In particular you will note that if you were to require that your expression x'*M*x above be real and non-negative for all complex vectors x, then M must necessarily be Hermitian. If you only require that the real part of x'*M*x be non-negative for all complex x, then that would allow M to be non-Hermitian.

Here are the web sites and quotations which I refer you to:
----
http://en.wikipedia.org/wiki/Positive-definite_matrix

"In linear algebra, a positive-definite matrix is a Hermitian matrix which in many ways is analogous to a positive real number."
----
http://mathworld.wolfram.com/PositiveSemidefiniteMatrix.html

"A positive semidefinite matrix is a Hermitian matrix all of whose eigenvalues are nonnegative."
----
http://www.halfvalue.com/wiki.jsp?topic=Positive-definite_matrix

"Non-Hermitian matrices
A real matrix M may have the property that xTMx > 0 for all nonzero real vectors x without being symmetric. The matrix

[1 1
 0 1]

provides an example. In general, we have xTMx > 0 for all real nonzero vectors x if and only if the symmetric part, (M + MT) / 2, is positive definite.

The situation for complex matrices may be different, depending on how one generalizes the inequality z*Mz > 0. If z*Mz is real for all complex vectors z, then the matrix M is necessarily Hermitian. So, if we require that z*Mz be real and positive, then M is automatically Hermitian. On the other hand, we have that Re(z*Mz) > 0 for all complex nonzero vectors z if and only if the Hermitian part, (M + M*) / 2, is positive definite.

In summary, the distinguishing feature between the real and complex case is that, a bounded positive operator on a complex Hilbert space is necessarily Hermitian, or self adjoint. The general claim can be argued using the polarization identity. That is no longer true in the real case.

There is no agreement in the literature on the proper definition of positive-definite for non-Hermitian matrices."
\---

Roger Stafford

Subject: generate a positive semi-definite matrices??
From: James Tursa
Date: 11 Feb, 2008 08:58:50
Message: 8 of 12

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On Sun, 10 Feb 2008 19:52:17 GMT, James Tursa <aclassyguywithaknotac@hotmail.com> wrote:
\>A Hermitian matrix (i.e., where isequal(M,M') is true) *will* be
\>positive semi-definite ...

groan ... I meant to write that a Hermitian matrix has real eigenvalues, not that it is necessarily positive semi-definite.

Subject: generate a positive semi-definite matrices??
From: Lanyi Xu
Date: 11 Feb, 2008 14:23:02
Message: 9 of 12

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James Tursa <aclassyguywithaknotac@hotmail.com> wrote in
message <7930r31i4p1uenb58ac90nve3giru5el1a@4ax.com>...
> On Sun, 10 Feb 2008 19:52:17 GMT, James Tursa
> <aclassyguywithaknotac@hotmail.com> wrote:
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will be
> >positive semi-definite ...
>
> *groan* ... I meant to write that a Hermitian matrix has
real
> eigenvalues, not that it is necessarily positive semi-
definite.

let's
a =

    0.8147 0.9134 0.2785
    0.9058 0.6324 0.5469
    0.1270 0.0975 0.9575
then;
>> ata=a'*a;
>> eig(ata)

ans =

```
   0.0329
   0.7038
   3.3007

>> ata2=(a'+a);
>> eig(ata2)

ans =

  -0.4007
   1.6130
   3.5969
```

So, that means (a'+a)/2 may not be a positive-define matrix.

Regard

Lanyi

Subject: generate a positive semi-definite matrices??
From: Pablo Ñañez
Date: 9 Nov, 2012 17:29:20
Message: 10 of 12

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I have created this little script that can help you, it creates a PD random matrix and then creates the symmetric version of the original matrix. I hope that this works for you.

Pablo.

```
% This script generates random positive definite symmetric matrices of size
n.
% By Pablo Nanez (Ñañez)
function [Q] = randPDsymmMatix(n)
Q = randn(n);
Q = Q*Q';
Q = symmetry(Q,1);
fprintf('The eigenvalues\n')
eig(Q)
end

function [A] = symmetry(A,tipo)
% Funcion para hacer la matriz simetrica de A
% Tipo: 1: matriz simetrica con signos
% Tipo: -1: matriz simetrica con signos contrarios
% e.g., D = simetria(D,1);
[f c] = size(A);
for iff = 1:f
   for ic = 1:c
      if isempty(A(iff,ic)) || A(iff,ic)==0
      else
         A(ic,iff) = tipo*A(iff,ic);
      end
```

```
  end
end
end
```

Subject: generate a positive semi-definite matrices??
From: Muhammad Asim Mubeen
Date: 25 Apr, 2014 19:54:00
Message: 11 of 12

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You can use the following function:

http://www.mathworks.com/matlabcentral/fileexchange/45873-positive-definite-matrix

Subject: generate a positive semi-definite matrices??
From: Steven Lord
Date: 25 Apr, 2014 21:32:18
Message: 12 of 12

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"Muhammad Asim Mubeen" <muhammmdeletemad_asimm@yahoo.com>
wrote in message
news:ljeegosln1@newscl01ah.mathworks.com...
> You can use the following function:

>
> http://www.mathworks.com/matlabcentral/fileexchange/45873-positive-definite-matrix

Some of the options for the GALLERY function may be of interest in solving this problem.

http://www.mathworks.com/help/matlab/ref/gallery.html

The options 'gcdmat', 'randcorr', and 'toeppd' specifically mention generating positive semidefinite matrices (or being able to generate a random positive semidefinite matrix using the matrix returned by 'gcdmat'.)

--
Steve Lord
slord@mathworks.com
To contact Technical Support use the Contact Us link on
http://www.mathworks.com

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