Comparing Matlab, Mathematica and Maple numerical speed for matrix rank calculation

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1 Introduction

This is an informal test comparing speed of Matlab, Mathematica and Maple on one common computational problem which is finding the rank of a square matrix.

For each $N \times N$ matrix, 5 tests were run and the average value used. During running each test, the PC was not used as not to affect the test and no other programs were running. The PC used has 16 GB RAM, running 64 bit Windows 7 home premium OS.

2 Test on Sept. 2, 2016. Matlab 2016a (64 bit), Maple 2016.1 (64 bit), Mathematica 11 (64 bit)

The time given is in seconds.

Mathematica 11 score in this test went down from earlier test, while Maple and Matlab score went up. This issue seems to be due to the intel MKL version that the software is linked to.

More information on this can be found here cpu-timing-for-matrix-rank-calculation-difference-between-10-3-and-10-4-and-11-0

3 Test on June 5, 2015 using Matlab 2015a (64 bit), Maple 2015.1 (64 bit) and Mathematica 10.1 (64 bit)

This test was run again for the new release of Mathematica 10.1 and a minor update for Maple 2015 to 2015.1. No changes were made to Matlab version or to the PC used from the last test and hence the Matlab test results were carried over from the last test.

matrix size (N)	Maple 2016.1 (64 bit)	Mathematica 11 (64 bit)	Matlab 2016a (64 bit)
500	0.036	0.024	0.0414
1000	0.141	0.134	0.138
1500	0.650	0.616	0.634
2000	2.08	2.033	2.053
2500	4.548	4.504	4.549
3000	2.313	8.393	2.595
3500	3.523	13.865	3.465
4000	5.215	22.088	5.052
4500	7.108	30.846	6.89
5000	8.129	43.079	8.005
5500	10.375	58.216	10.181
6000	13.543	75.655	13.466
6500	15.884	96.048	15.915
7000	19.673	120.505	19.000
7500	23.141	148.593	22.529
8000	28.789	180.311	28.095

Table 1: Results Matlab 2016a (64 bit), Maple 2016.1 (64 bit), Mathematica 11 (64 bit)

Hardware used for this test is exactly the same as last time, and no changes made in the tests themselves.

The time given is in seconds. This is the time to find the rank for different matrix sizes (lower time is better). The results are in table 2 below.

matrix size (N)	Maple 2015.1 (64 bit)	Mathematica 10.1 (64 bit)	Matlab 2015a (64 bit)
500	0.046	0.03	0.04
1000	0.18	0.14	0.18
1500	0.71	0.65	0.66
2000	2.16	2.15	2.01
2500	4.8	4.66	4.61
3000	8.85	2.25(*)	8.6
3500	14.48	3.42	14.05
4000	22.08	4.98	21.5
4500	32.18	6.97	31.1
5000	45.29	7.80	43.3
5500	60.3	9.66	58.4
6000	77.6	12.81	76.9
6500	100.1	14.70	97.5
7000	123.7	17.82	122.1
7500	153.9	22.49	151.9
8000	184.2	27.03	182.9

Table 2: Results Matlab 2015a (64 bit), Maple 2015.1 (64 bit), Mathematica 10.1 (64 bit)

Mathematica 10.1 was surprisingly much faster on this test than 10.0.2. It seems Mathematica 10.1 is using different algorithm to compute the rank now to account for this drastic difference in speed improvement.

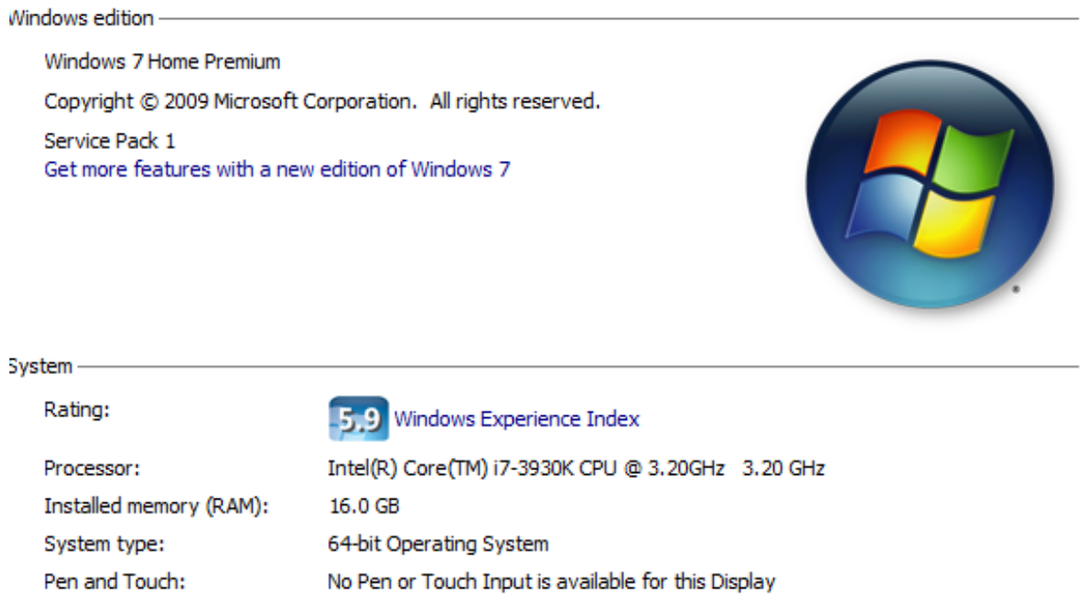
The speed boost was observed to occur at certain matrix size. At matrix size of 2500 or less, the same speed was obtained as with version 10.0.2. At matrix size over 2500, even by just one, a dramatic speed increase was seen. For $n=2500$ Mathematica CPU was around 4.6 seconds which is the same as in 10.0.2, but by increasing the matrix size to $n=2501$, CPU time went down to about 1.4 seconds. This is 3 times as fast for essentially the same matrix size. This result was reproducible. This seems to indicate that Mathematica internally uses the same algorithm as previous version for smaller size matrices, and then switches to different algorithm for larger matrices.

There was no noticeable change in Maple's speed in this test between 2015 and Maple 2015.1.

4 Test on March 11, 2015 using Matlab 2015a (64 bit), Maple 2015 (64 bit) and Mathematica 10.02 (64 bit)

Updated the test for the now released Maple 2015 (which would have been Maple 19) but the naming changed. Also updated for Matlab 2015a (64 bit) released on March 5, 2015.

Hardware used for this test is exactly the same as earlier test on July 2014, which is



The time given is in seconds. This is the time to find the rank for different matrix sizes (lower time is better). The results are in table 3 below.

matrix size (N)	Maple 2015 (64 bit)	Mathematica 10.02 (64 bit)	Matlab 2015a (64 bit)
500	0.043	0.047	0.04
1000	0.175	0.157	0.18
1500	0.64	0.67	0.66
2000	2.1	2.11	2.01
2500	4.8	4.67	4.61
3000	8.7	8.79	8.6
3500	14.5	14.15	14.05
4000	22.2	21.67	21.5
4500	31.7	31.42	31.1
5000	43.6	43.07	43.3
5500	57.9	58.8	58.4
6000	76.3	77.24	76.9
6500	96.7	98.21	97.5
7000	121.8	122.1	122.1
7500	151.2	151.81	151.9
8000	182.3	183.1	182.9

Table 3: Results Matlab 2015a (64 bit), Maple 2015 (64 bit), Mathematica 10.02 (64 bit)

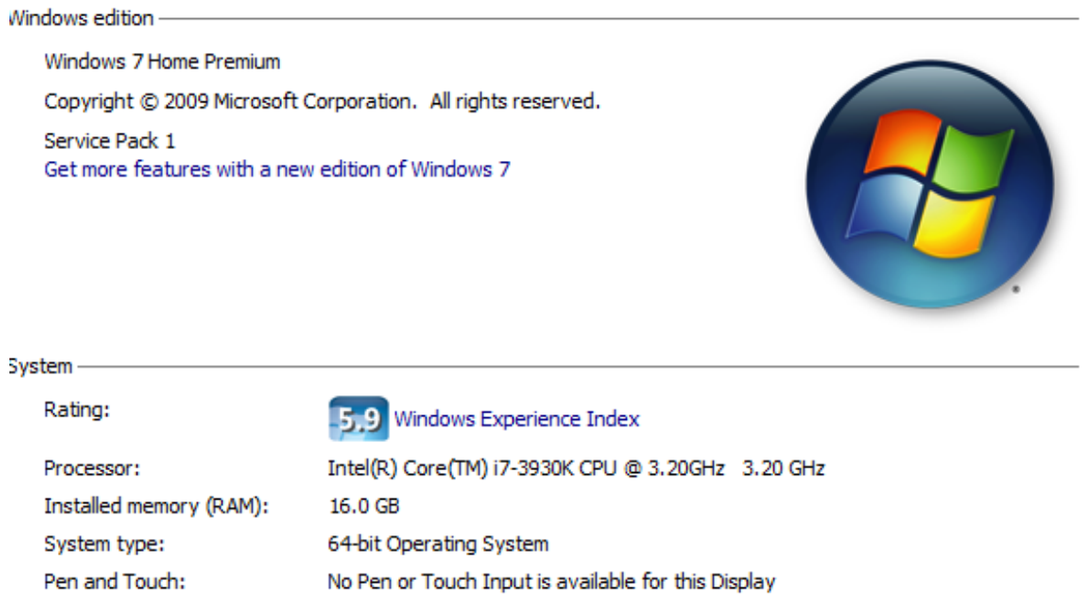
Finally, **Maple now runs as fast as Mathematica and Matlab on this test**. All three systems now have identical speed performance on this numerical test.

This indicates Maple 2015 is now using and linked to the same version of Intel optimized numerical libraries used by Matlab and Mathematica. On windows this will be intel math kernel library

The source code for the test is in the section below. No changes were made to the tests from last time.

5 Test on July 28, 2014 using Matlab 2013a (32 bit), Maple 18.01 (64 bit) and Mathematica 10 (64 bit)

Hardware used for this test



The time given is in seconds. This is the time to find the rank for different matrix sizes (lower time is better). The results are in table 4 below.

matrix size (N)	Maple 18.01, 64 bit	Mathematica 10, 64 bit	Matlab 2013a, 32 bit
500	0.07	0.031	0.043
1000	0.350	0.163	0.16
1500	1.46	0.72	0.63
2000	3.75	2.13	2.0
2500	7.47	4.72	4.5
3000	12.75	8.65	8.4
3500	19.85	14.22	14
4000	28.5	22.3	21.2
4500	40.5	31.23	30.8
5000	56.4	43.4	43
5500	73.65	58.14	58
6000	95.85	77.11	76
6500	124.84	97.61	96.5
7000	153.51	120.96	121.5
7500	199.4	149.58	150
8000	240.59	181.39	183

Table 4: Results Matlab 2013a (32 bit), Maple 18.01 (64 bit), Mathematica 10 (64 bit)

Matlab and Mathematica results are almost **identical**. This is most likely due to the fact that they both are linked to optimized versions of same numerical libraries. On windows this will be intel math kernel library

Maple 18.01 result is similar to its results in version 17 below. It seems to improve as the matrix size became larger, but its overall timing was still about 25% slower than timing of Matlab and Mathematica. It appears that Maple does not use intel-mkl or uses different version or the extra CPU time used comes from other operations done internally. Hard to say.

Matlab results are the same as those from the test below and used as is, since the same Matlab version and same PC and same amount of RAM was used in this test as the one below done on March 26, 2013. Only Maple and Mathematica versions has changed since then.

Description of the timing functions used is as follows

Maple Command `time[real](x)` was used. Returns the real time used to evaluate expression x.

Mathematica Command `AbsoluteTiming` was used. Evaluates expr, returning a list of the absolute number of seconds in real time that have elapsed.

Matlab Functions tic and toc were used. Work together to measure elapsed time.

5.1 Mathematica code

```
(*kernel is restarted before each test as well*)
Remove["Global`*"];
$HistoryLength = 0;
Share[];
n = 7000;
m = RandomReal[{}, {n, n}];
AbsoluteTiming[MatrixRank[m];]
```

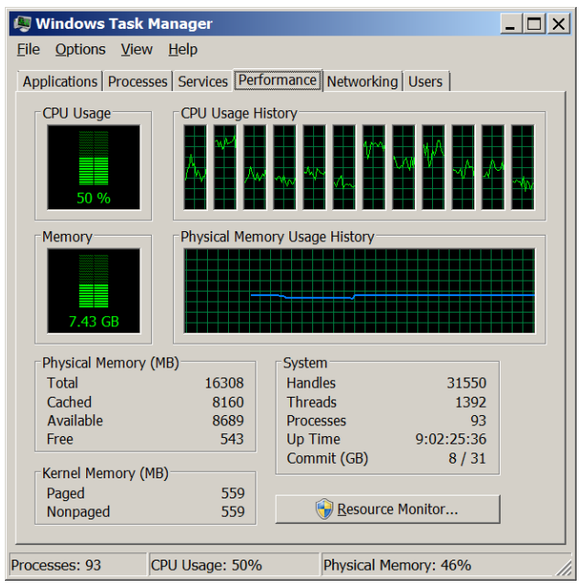
5.2 Maple

```
restart;
kernelopts(gcfreq= 2^22):
UseHardwareFloats:= true:
gc():

n:=7000:
M:= LinearAlgebra:-RandomMatrix(
     n
    ,n
    ,generator=0.0 .. 1
    ,outputoptions=[datatype=float[8]]
):

time[real](LinearAlgebra:-LA_Main:-Rank(M));
```

5.3 Matlab

```
clear all;
n=2500;
A=rand(n,n);
tic();
rank(A);
toc()
```

This is a screen shot showing typical memory and CPU usage during running of these tests on my PC



6 Test on March 26, 2013 using Matlab 2013a, Maple 17 and Mathematica 9.01

Hardware used is the same as above and timing functions are the same as above. The time given is in seconds. This is the time to find the rank for different matrix sizes (lower time is better). The results are in table 5 below.

matrix size (N)	Maple 17, 64 bit	Mathematica 9.01, 64 bit	Matlab 2013a, 32 bit
500	0.07	0.0312	0.043
1000	0.38	0.17	0.16
1500	1.5	0.65	0.63
2000	3.8	2.16	2.0
2500	7.8	4.68	4.5
3000	13	8.67	8.4
3500	20.9	14.1	14
4000	29	21.2	21.2
4500	42	30.9	30.8
5000	58	43.4	43
5500	75	58	58
6000	98	76	76
6500	124	96	96.5
7000	152	122	121.5
7500	198	150	150
8000	237	183	183

Table 5: Results Matlab 2013a, Maple 17, Mathematica 9.01

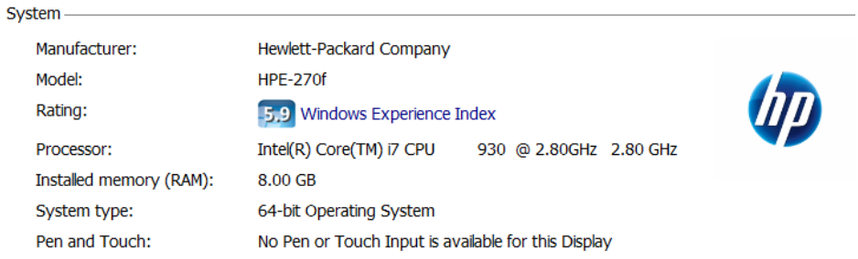
Matlab and Mathematica results are **identical**. This is most likely due to the fact that they both are linked to optimized versions of same numerical libraries. On windows this will be intel math kernel library

Maple result seems to improve as the matrix size became larger, but its overall timing was still about 25% slower than timing of Matlab and Mathematica.

7 Test done in 2010 using current version of software at that time

This test is now old and not valid any more since new version of software exist. This is kept here for archiving only.

Hardware used for this test



In the table below, the first column is N, the matrix size. All values in the matrix are in seconds.

```
     +--------------+---------------+----------------+
     |   Maple      |  Mathematica  |  Matlab        |
     |----+----+----+----+-----+----+-----+----+-----+
     |Rand|Rank|tot |Rand|Rank |tot |Rand |Rank|tot  |
+----+--------------+----+-----+----+-----+----+-----+
|500 |.031|.545|.56 |0.04|0.55 |0.56|0.04 |0.9 |0.94 |
+----+----+----+----+----+-----+----+-----+----+-----+
|1000|0.11|3.74|3.84|.2  |3.8  | 4  |.11  |5.7 |5.8  |
+----+----+----+----+----+-----+----+-----+----+-----+
|1500|0.25|11.7|11.9|.4  |12.3 |12.7|.14  |22  |22.15|
+----+----+----+----+----+-----+----+-----+----+-----+
|2000|0.42|29.8|30.2|.75 |30   |31  |.26  |44  |44.3 |
+----+----+----+----+---------------+-----+----+-----+
|2500|0.67|50.6|51.2|1.2 |55   |56  |.34  |96  |96.3 |
+----+----+----+----+----+-----+----+-----+----+-----+
|3000|0.98|94  |95  |1.8 |85   |87  |.47  |142 | 143 |
+----+----+----+----+----+-----+----+-----+----+-----+
|3500|1.3 |167 |170 |2.3 |132  |135 |.61  |262 | 263 |
+----+----+----+----+----+-----+----+-----+----+-----+
|4000|1.75|*   |    |3.27|236  |240 |.83  |340 | 341 |
+----+----+----+----+----+-----+----+-----+----+-----+
|4500|2.15|*   |    |3.98|304  |308 |.93  |545 | 546 |
+----+----+----+----+----+-----+----+-----+----+-----+
|5000|2.67|*   |    |4.7 |425  |430 |1.46 |671 | 672 |
+----+----+----+----+----+-----+----+-----+----+-----+

          (*): Maple gave this error:
   Error, (in Matrix) not enough memory to allocate rtable
```

7.1 conclusion for 2010 tests

For generation of random matrix, Maple was close second to Matlab for smaller Matrix sizes, then Matab pulled ahead as the matrix size increased.

But overall for all 3 systems, this part took insignificant amount of time compared to rank calculation. So this part did not affect the overall performance.

For Rank calculation, Maple and Mathematica performance was very close to each others for small size matrices. Almost identical performance. This was up to matrix of size 2500.

Mathematica performance then became a little better compared to Maple's. At Matrix size 4000×4000 Maple test was terminated due to a failed memory error problem. The amount of RAM needed is $(4000)(4000)(8)(4)=512$ MB.

This error should not therefore occur. It seems to be an internal problem in Maple since both Matlab and Mathematica are able to handle up to 5000×5000 matrices.

Mathematica was almost 60% faster than Matlab for 5000×5000 matrix rank calculation. This is a very good result for Mathematica.

Matlab was the fastest in all the tests for the Random matrix generation.

7.2 source code used

7.3 Maple

```
> restart;
> kernelopts(gcfreq= 2^22):
> UseHardwareFloats:= true:
> gc():
>
> n:=3500:
> t0:= time():
>
> M:= LinearAlgebra:-RandomMatrix(
>     n
>    ,n
>    ,generator=0.0 .. 1
>    ,outputoptions=[datatype=float[8]]
> ):
>
> #gc():
> randTime:= time()-t0;
> LinearAlgebra:-LA_Main:-Rank(M):
> rankTime:= time()-(t0+randTime);
> total:=rankTime+randTime;
```

7.4 Mathematica

```
Remove["Global`*"];
Share[];
n = 4000;
Timing[m = Table[Random[], {i, 1, n}, {j, 1, n}]; ]
Timing[MatrixRank[m]]
```

7.5 Matlab

```
n=5000;
t=cputime;
A=rand(n,n);
cputime-t
t=cputime;
rank(A);
cputime-t
```