# GPU Programming Fall 2021 - HW1

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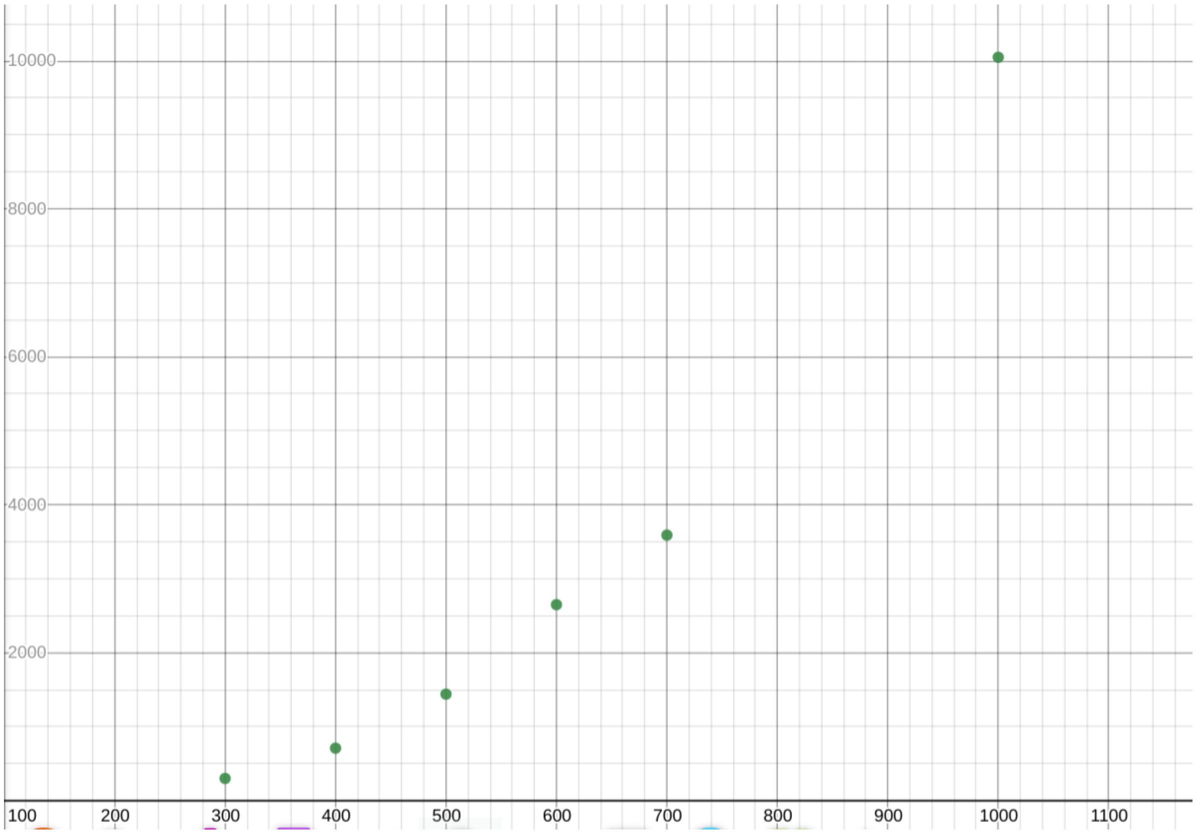
The assignment given in this homework was that we had to benchmark a matrix multiplication code using gprof.

The multiplication included three main functions. matmat_ijk , matmat_jki and matmat_ikj. For us to compile the source code “matmat_cxx.cc” we had to alter the MakeFile flags “CXXFLAGS” because gprof simply wouldn't give us the expected results. The flags “-03” and “-funroll-loops” were removed and “-pg” was added.

The “make” command was used to compile the source code. Then the “gmon.out” file was created using the “./matmat_cxx” command which runs the code. Then we used the “gprof matmat_cxx gmon.out > profiling_results/dimesnsions_xxx.txt”.

This process was done for dimensions 300 through 700 plus one with 1000 just for the fun of it.

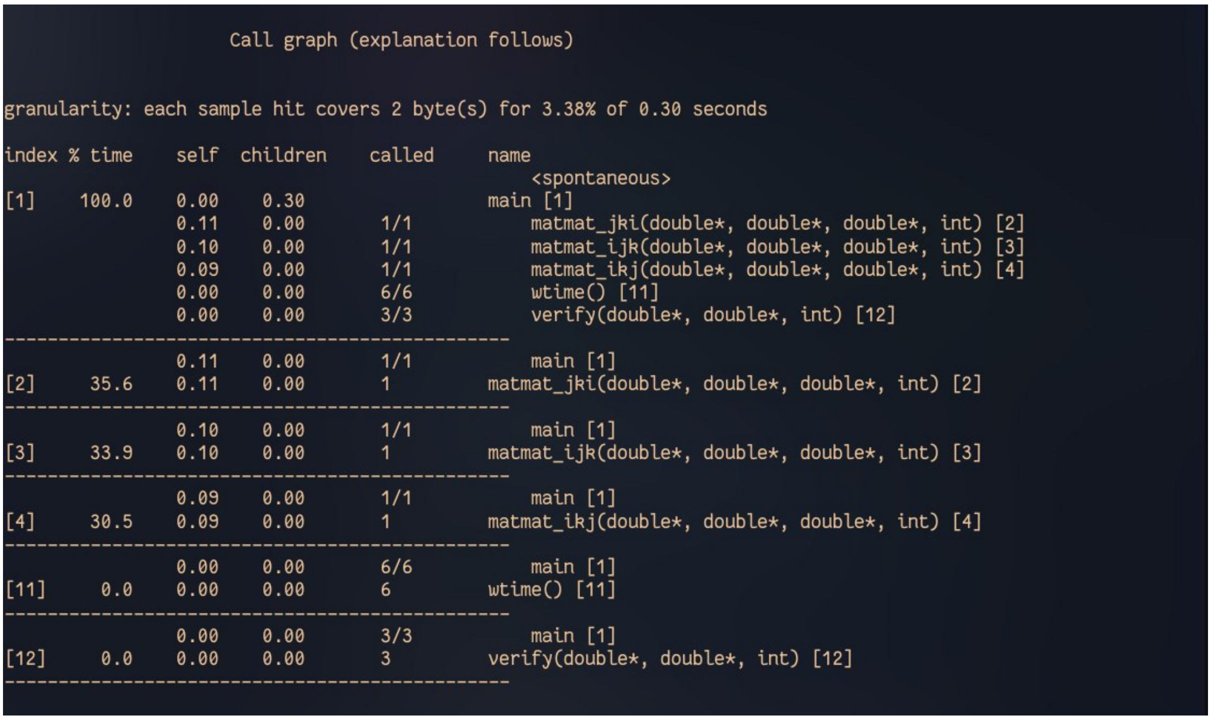
The results show us that except for the 300 dimension which the jki function takes the most time, in all other dimensions tried, the ijk function takes most of the time which is around 35-39% of the total time. The jki function takes about 34-35% of the whole time and the ikj function takes about 25-29%. The remaining time is split between the wtime and verify functions which are not very time consuming.



The graph above shows the x-axis as the dimensions and the y-axis as the total time in milliseconds.

The followings are the call graphs for each dimension tried:

For the 300x300 dimension:

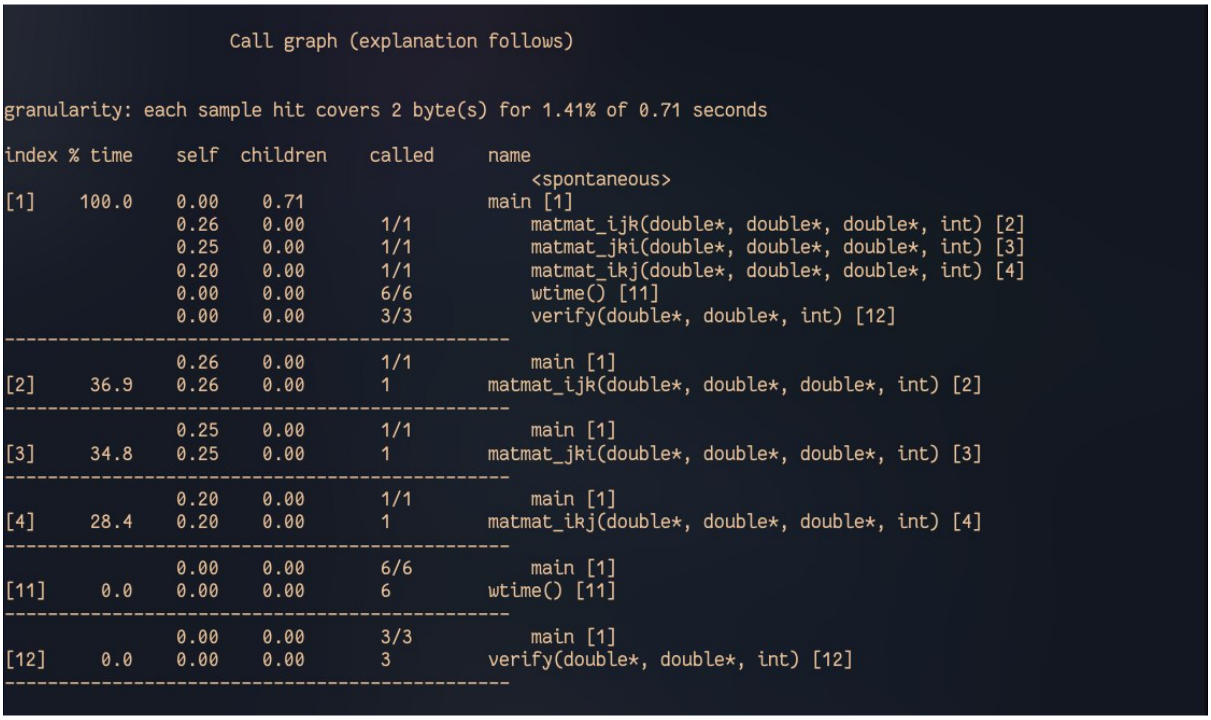


```
                     Call graph (explanation follows)


granularity: each sample hit covers 2 byte(s) for 3.38% of 0.30 seconds

index % time    self  children    called     name
                                                 <spontaneous>
[1]    100.0    0.00    0.30                 main [1]
                0.11    0.00       1/1           matmat_jki(double*, double*, double*, int) [2]
                0.10    0.00       1/1           matmat_ijk(double*, double*, double*, int) [3]
                0.09    0.00       1/1           matmat_ikj(double*, double*, double*, int) [4]
                0.00    0.00       6/6           wtime() [11]
                0.00    0.00       3/3           verify(double*, double*, int) [12]
-----------------------------------------------
                0.11    0.00       1/1           main [1]
[2]     35.6    0.11    0.00       1         matmat_jki(double*, double*, double*, int) [2]
-----------------------------------------------
                0.10    0.00       1/1           main [1]
[3]     33.9    0.10    0.00       1         matmat_ijk(double*, double*, double*, int) [3]
-----------------------------------------------
                0.09    0.00       1/1           main [1]
[4]     30.5    0.09    0.00       1         matmat_ikj(double*, double*, double*, int) [4]
-----------------------------------------------
                0.00    0.00       6/6           main [1]
[11]     0.0    0.00    0.00       6         wtime() [11]
-----------------------------------------------
                0.00    0.00       3/3           main [1]
[12]     0.0    0.00    0.00       3         verify(double*, double*, int) [12]
-----------------------------------------------
```

For the 400x400 dimension:

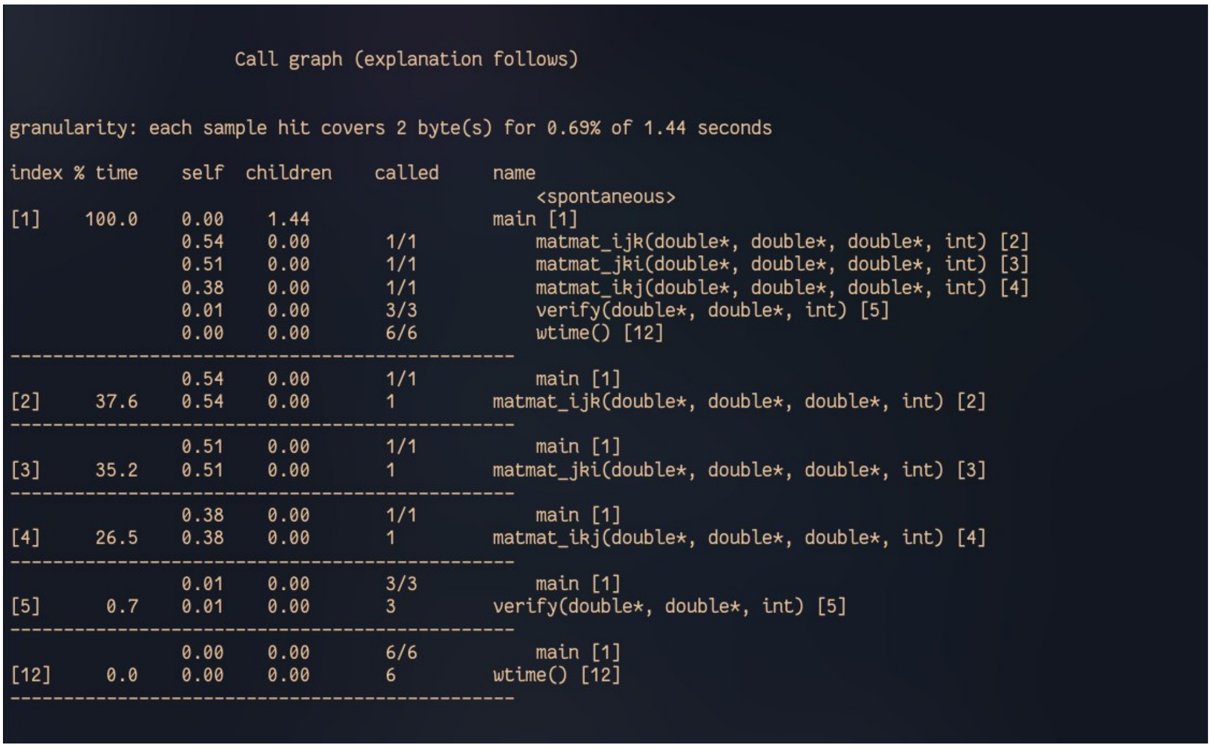


```
                     Call graph (explanation follows)


granularity: each sample hit covers 2 byte(s) for 1.41% of 0.71 seconds

index % time    self  children    called     name
                                                 <spontaneous>
[1]    100.0    0.00    0.71                 main [1]
                0.26    0.00       1/1           matmat_ijk(double*, double*, double*, int) [2]
                0.25    0.00       1/1           matmat_jki(double*, double*, double*, int) [3]
                0.20    0.00       1/1           matmat_ikj(double*, double*, double*, int) [4]
                0.00    0.00       6/6           wtime() [11]
                0.00    0.00       3/3           verify(double*, double*, int) [12]
-----------------------------------------------
                0.26    0.00       1/1           main [1]
[2]     36.9    0.26    0.00       1         matmat_ijk(double*, double*, double*, int) [2]
-----------------------------------------------
                0.25    0.00       1/1           main [1]
[3]     34.8    0.25    0.00       1         matmat_jki(double*, double*, double*, int) [3]
-----------------------------------------------
                0.20    0.00       1/1           main [1]
[4]     28.4    0.20    0.00       1         matmat_ikj(double*, double*, double*, int) [4]
-----------------------------------------------
                0.00    0.00       6/6           main [1]
[11]     0.0    0.00    0.00       6         wtime() [11]
-----------------------------------------------
                0.00    0.00       3/3           main [1]
[12]     0.0    0.00    0.00       3         verify(double*, double*, int) [12]
-----------------------------------------------
```

For the 500x500 dimension:

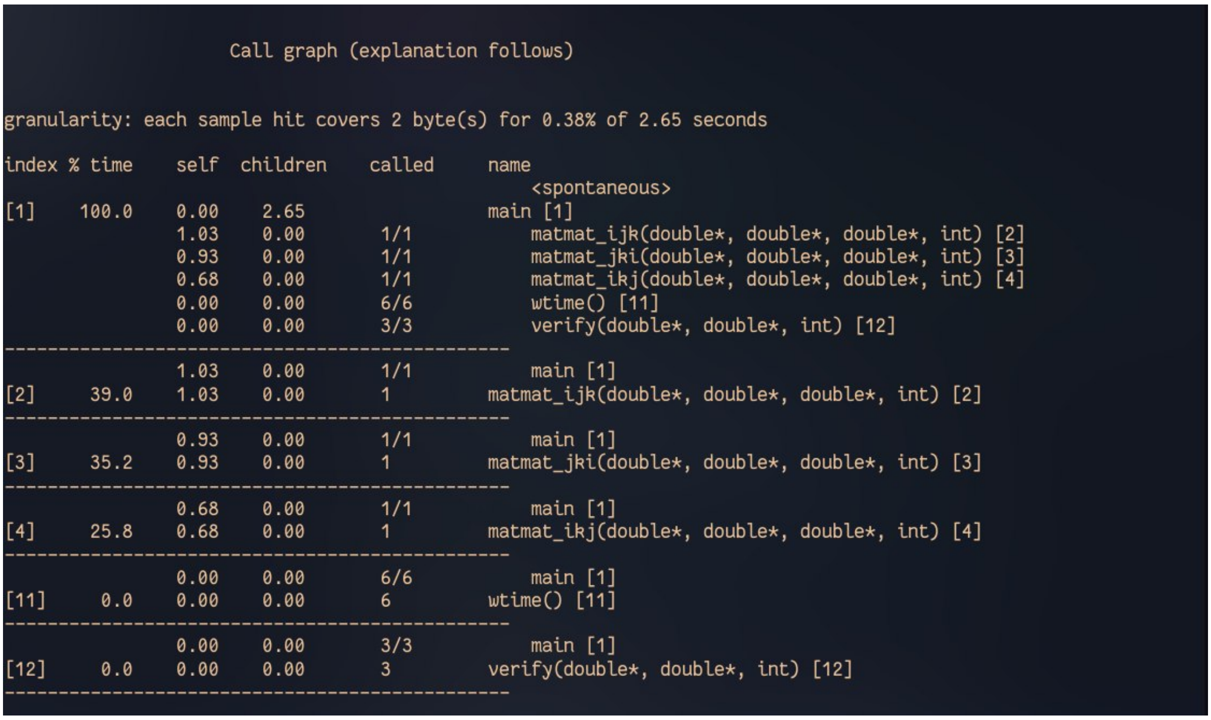


```
                     Call graph (explanation follows)


granularity: each sample hit covers 2 byte(s) for 0.69% of 1.44 seconds

index % time    self  children    called     name
                                                 <spontaneous>
[1]    100.0    0.00    1.44                 main [1]
                0.54    0.00       1/1           matmat_ijk(double*, double*, double*, int) [2]
                0.51    0.00       1/1           matmat_jki(double*, double*, double*, int) [3]
                0.38    0.00       1/1           matmat_ikj(double*, double*, double*, int) [4]
                0.01    0.00       3/3           verify(double*, double*, int) [5]
                0.00    0.00       6/6           wtime() [12]
-----------------------------------------------
                0.54    0.00       1/1           main [1]
[2]     37.6    0.54    0.00       1         matmat_ijk(double*, double*, double*, int) [2]
-----------------------------------------------
                0.51    0.00       1/1           main [1]
[3]     35.2    0.51    0.00       1         matmat_jki(double*, double*, double*, int) [3]
-----------------------------------------------
                0.38    0.00       1/1           main [1]
[4]     26.5    0.38    0.00       1         matmat_ikj(double*, double*, double*, int) [4]
-----------------------------------------------
                0.01    0.00       3/3           main [1]
[5]      0.7    0.01    0.00       3         verify(double*, double*, int) [5]
-----------------------------------------------
                0.00    0.00       6/6           main [1]
[12]     0.0    0.00    0.00       6         wtime() [12]
-----------------------------------------------
```

For the 600x600 dimension:

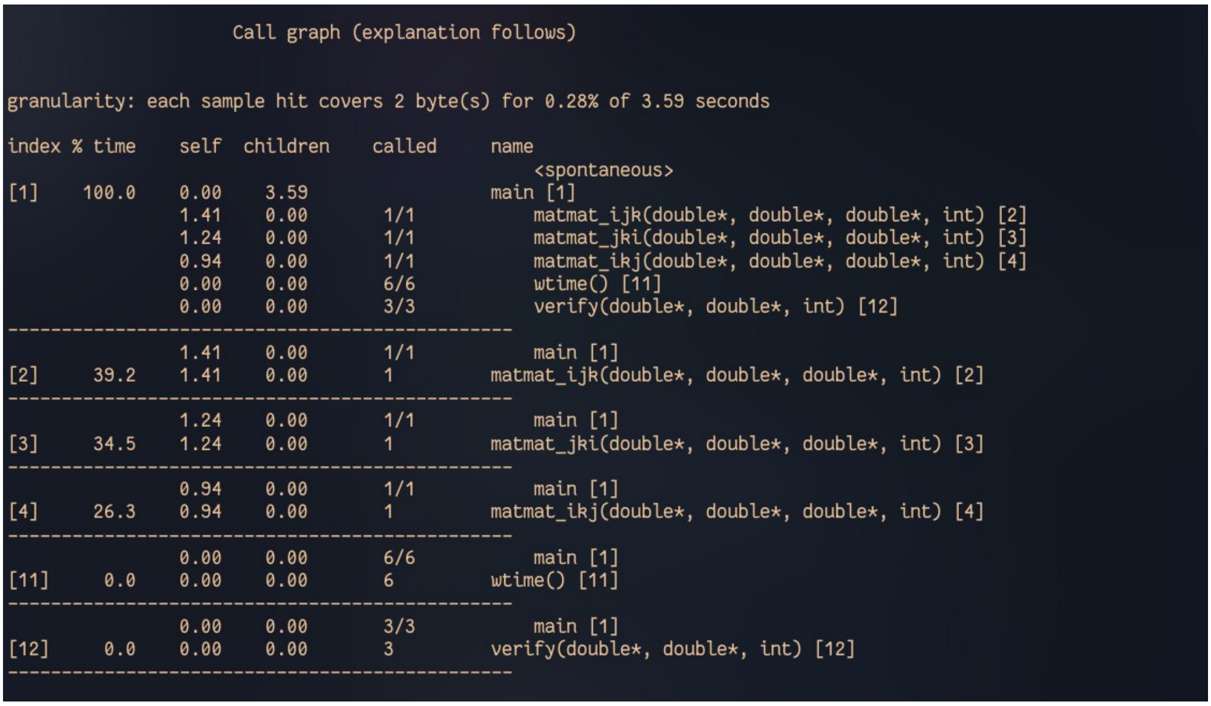


```
                     Call graph (explanation follows)


granularity: each sample hit covers 2 byte(s) for 0.38% of 2.65 seconds

index % time    self  children    called     name
                                                 <spontaneous>
[1]    100.0    0.00    2.65                 main [1]
                1.03    0.00       1/1           matmat_ijk(double*, double*, double*, int) [2]
                0.93    0.00       1/1           matmat_jki(double*, double*, double*, int) [3]
                0.68    0.00       1/1           matmat_ikj(double*, double*, double*, int) [4]
                0.00    0.00       6/6           wtime() [11]
                0.00    0.00       3/3           verify(double*, double*, int) [12]
-----------------------------------------------
                1.03    0.00       1/1           main [1]
[2]     39.0    1.03    0.00       1         matmat_ijk(double*, double*, double*, int) [2]
-----------------------------------------------
                0.93    0.00       1/1           main [1]
[3]     35.2    0.93    0.00       1         matmat_jki(double*, double*, double*, int) [3]
-----------------------------------------------
                0.68    0.00       1/1           main [1]
[4]     25.8    0.68    0.00       1         matmat_ikj(double*, double*, double*, int) [4]
-----------------------------------------------
                0.00    0.00       6/6           main [1]
[11]     0.0    0.00    0.00       6         wtime() [11]
-----------------------------------------------
                0.00    0.00       3/3           main [1]
[12]     0.0    0.00    0.00       3         verify(double*, double*, int) [12]
-----------------------------------------------
```

For the 700x700 dimension:

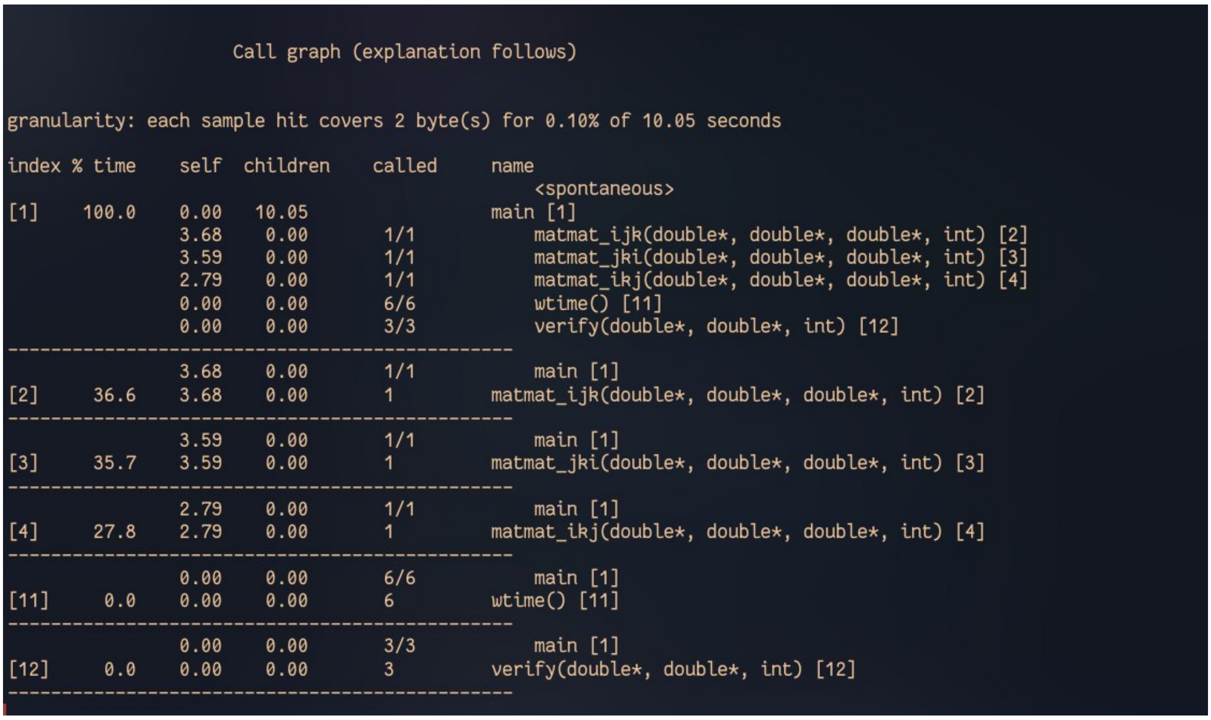


```
                     Call graph (explanation follows)


granularity: each sample hit covers 2 byte(s) for 0.28% of 3.59 seconds

index % time    self  children    called     name
                                                 <spontaneous>
[1]    100.0    0.00    3.59                 main [1]
                1.41    0.00       1/1           matmat_ijk(double*, double*, double*, int) [2]
                1.24    0.00       1/1           matmat_jki(double*, double*, double*, int) [3]
                0.94    0.00       1/1           matmat_ikj(double*, double*, double*, int) [4]
                0.00    0.00       6/6           wtime() [11]
                0.00    0.00       3/3           verify(double*, double*, int) [12]
-----------------------------------------------
                1.41    0.00       1/1           main [1]
[2]     39.2    1.41    0.00       1         matmat_ijk(double*, double*, double*, int) [2]
-----------------------------------------------
                1.24    0.00       1/1           main [1]
[3]     34.5    1.24    0.00       1         matmat_jki(double*, double*, double*, int) [3]
-----------------------------------------------
                0.94    0.00       1/1           main [1]
[4]     26.3    0.94    0.00       1         matmat_ikj(double*, double*, double*, int) [4]
-----------------------------------------------
                0.00    0.00       6/6           main [1]
[11]     0.0    0.00    0.00       6         wtime() [11]
-----------------------------------------------
                0.00    0.00       3/3           main [1]
[12]     0.0    0.00    0.00       3         verify(double*, double*, int) [12]
-----------------------------------------------
```

And for the 1000x1000 dimension:



```
                     Call graph (explanation follows)


granularity: each sample hit covers 2 byte(s) for 0.10% of 10.05 seconds

index % time    self  children    called     name
                                                 <spontaneous>
[1]    100.0    0.00   10.05                 main [1]
                3.68    0.00       1/1           matmat_ijk(double*, double*, double*, int) [2]
                3.59    0.00       1/1           matmat_jki(double*, double*, double*, int) [3]
                2.79    0.00       1/1           matmat_ikj(double*, double*, double*, int) [4]
                0.00    0.00       6/6           wtime() [11]
                0.00    0.00       3/3           verify(double*, double*, int) [12]
-----------------------------------------------
                3.68    0.00       1/1           main [1]
[2]     36.6    3.68    0.00       1         matmat_ijk(double*, double*, double*, int) [2]
-----------------------------------------------
                3.59    0.00       1/1           main [1]
[3]     35.7    3.59    0.00       1         matmat_jki(double*, double*, double*, int) [3]
-----------------------------------------------
                2.79    0.00       1/1           main [1]
[4]     27.8    2.79    0.00       1         matmat_ikj(double*, double*, double*, int) [4]
-----------------------------------------------
                0.00    0.00       6/6           main [1]
[11]     0.0    0.00    0.00       6         wtime() [11]
-----------------------------------------------
                0.00    0.00       3/3           main [1]
[12]     0.0    0.00    0.00       3         verify(double*, double*, int) [12]
-----------------------------------------------
```