# Short README for GPU computations

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Running GPU computations on MATLAB is only possible on suitable systems, and with sufficient MATLAB license (and installation). We do not provide full instructions to get the system up and running, but give three illustrative examples of possible errors.

# Systems producing three possible errors, and one fully successful system

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| **System description** | **Output from short script** | **Output from thorough script** |
| Test computer is a fanless ultraportable, with dual-core CPU “Intel Core m3-7Y30 @ 1.00 GHz”. It is running MATLAB R2018a on Windows 10 (version 1809).  Error:  MATLAB without needed toolboxes, in this case “Parallel Computing Toolbox”.  Solution:  Install “Parallel Computing Toolbox”, try again. | **>> Example\_3shellForward\_Short**  Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 46.386573 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  To use 'gpuDevice', the following product must be licensed, installed, and enabled:  Parallel Computing Toolbox  Error in Example\_3shellForward\_Short (line 66)  gpustat=gpuDevice(1); | **>> Example\_3shellForward\_Thorough**  Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 44.038938 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  MATLAB Parallel Computing Toolbox is not installed.  No GPU acceleration available, “simulating” GPU with CPU!  With GPU ('CPU simulation'): solved 3D field in 9000 points for 181 coil positions in 14.3 s  No GPU: solved 3D field in 9000 points for 181 coil positions in 14.0 s |
| Test computer is a fanless ultraportable, with dual-core CPU “Intel Core m3-7Y30 @ 1.00 GHz” and low-end integrated GPU (Intel HD Graphics 615). It is running MATLAB R2018a on Windows 10 (version 1809).  Error:  There are no GPUs that support CUDA. In this case “gpuDeviceCount” returns 0.  Solution:  Use a computer with suitable recent nVidia GPU from last few years. MATLAB does not support other GPUs. | **>> Example\_3shellForward\_Short**  Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 42.378531 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  Error using gpuDevice (line 26)  There is a problem with the graphics driver or with this GPU device. Be sure that you have a supported GPU and that the latest driver is installed.  Error in Example\_3shellForward\_Short (line 66)  Caused by:  The CUDA driver could not be loaded. The library name used was 'nvcuda.dll'. The error was:  Määritettyä osaa ei löydy. | **>> Example\_3shellForward\_Thorough**  Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 47.005971 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  Found MATLAB Parallel Computing Toolbox.  No suitable GPU devices were found.  If you have an nVidia GPU try updating its drivers.  If not, you have to insert one into your computer.  No GPU acceleration available, “simulating” GPU with CPU!  With GPU ('CPU simulation'): solved 3D field in 9000 points for 181 coil positions in 17.9 s  No GPU: solved 3D field in 9000 points for 181 coil positions in 16.0 s |
| Test system is a mainstream laptop, i.e., not a workstation or gaming laptop. It has quad-core CPU (Intel Core i7-7700HQ), but only an entry-level discrete GPU (NVIDIA GeForce 940MX, 2 GB VRAM, from 2016). The memory bandwidth is 40.08 GB/s.  Errors:  1. Slow performance on GPU.  2. Out of memory on the full field.  Solution:  1. Select a GPU with faster memory bandwidth, the GPU in the manuscript had memory bandwidth of 192 GB/s, and 2019 high-end GPUs have memory bandwidths in excess of 600 GB/s.  2. Select a GPU with more VRAM, this usually also solves the bandwidth problem. | **>> Example\_3shellForward\_Short**  Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 22.299941 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  With GPU ('GeForce 940MX'): solved 3D field in 9000 points for 181 coil positions in 7.9 s  No GPU: solved 3D field in 9000 points for 181 coil positions in 12.3 s | **>> Example\_3shellForward\_Thorough**  Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 21.945406 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  Found MATLAB Parallel Computing Toolbox.  Found 1 GPU device(s).  Initialized GPU with model 'GeForce 940MX'.  Error using gpuArray  Out of memory on device. To view more detail about available memory on the GPU, use 'gpuDevice()'. If the problem persists, reset the GPU by calling 'gpuDevice(1)'.  Error in Example\_3shellForward\_Thorough (line 208)  Phiw\_gpu=gpuArray(Phiw); |
| The test system is that of the manuscript, with quad-core CPU (Intel Xeon E3-1230 v5) and a mid-tier GPU (NVIDIA GeForce GTX 1060 6 GB, from 2016). It is running MATLAB R2018a on Ubuntu 16.04 LTS. | Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 16.966263 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  With GPU ('GeForce GTX 1060 6GB'): solved 3D field in 9000 points for 181 coil positions in 2.0 s  No GPU: solved 3D field in 9000 points for 181 coil positions in 10.4 s | Building 9 D matrices; 1 2 3 4 5 6 7 8 9 done.  Elapsed time is 17.366965 seconds.  Inverting 7686 x 7686 matrix...OK.  Inverting 2562 x 2562 matrix...OK.  Found MATLAB Parallel Computing Toolbox.  Found 1 GPU device(s).  Initialized GPU with model 'GeForce GTX 1060 6GB'.  With GPU ('GeForce GTX 1060 6GB'): solved 3D field in 9000 points for 181 coil positions in 2.0 s  No GPU: solved 3D field in 9000 points for 181 coil positions in 10.5 s |