GPU Computing with MATLAB

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Why should you care?

- **MATLAB Programmers**
  - Acceleration MATLAB Code with GPUs
  - Minimal code changes

- **CUDA Programmers**
  - Prototype algorithms
  - Create test harnesses for your kernels
  - Quickly explore algorithm parameters
  - Analyze and visualize kernel results
What is MATLAB?

- High level language and development environment for:
  - Algorithm and application development
  - Data analysis
  - Mathematical modeling
  - GPU computing *

- Extensive math, engineering, and plotting functionality

- Add-on products for image and video processing, communications, signal processing, financial modeling, and more

- Over 1.3 million users worldwide

* Requires Parallel Computing Toolbox
Speed up MATLAB code with NVIDIA GPUs

10x *speedup* in data clustering via K-means clustering algorithm

20x *speedup* in wind tunnel acoustic data analysis (NASA Langley Research Center)

14x *speedup* in template matching (part of cancer cell image analysis)

17x *speedup* in simulating the movement of 3072 celestial objects

4x *speedup* in wave equation solving (part of seismic data processing algorithm)

4x *speedup* in adaptive filtering (part of acoustic tracking algorithm)
Demonstration: 2D wave equation

Goals
- Solve 2D wave equation in MATLAB
- Use GPU computing to speed-up algorithm

*Damped wave equation*

\[
\frac{\partial^2 u}{\partial t^2} = r^2 \nabla^2 u - b \frac{du}{dt}
\]

\[u_{t+1} = 2u_t - u_{t-1} + r^2 \nabla^2 u - b(u_t - u_{t-1})\]
Running MATLAB code on the GPU

- 200+ built-in MATLAB functions that are supported on the GPU
  - Random number generation
  - FFT
  - Matrix multiplications
  - Solvers
  - Convolutions
  - Min/max
  - SVD
  - Cholesky and LU factorization

- Additional support in toolboxes
  - **Image Processing**
    - Morphological filtering, 2-D filtering, …
  - **Communications**
    - Turbo, LDPC, and Viterbi decoders, …
  - **Signal Processing**
    - Cross correlation, FIR filtering, …

- Use `arrayfun` to execute custom functions on the GPU (more efficiently than doing each operation within function individually)
How can MATLAB support CUDA development?

**Research & Design**
- Explore and discover
- Gain insight into problem
- Evaluate options, trade-offs

**Implementation**
- Migrate design to production
- Optimize performance
- Deploy / Integrate / Test

**Test & Verification**
- Design
- Test
- Elaborate

- .exe
- .NET
- dll
- CUDA
- .C/C++
- Java
- HDL
Demonstration: 2D wave equation

Goals

- Develop 2D wave equation solver in CUDA C/C++
- Use MATLAB to support CUDA development
Summary

- Develop GPU applications in MATLAB
  - Built-in GPU enabled functionality
  - `arrayfun` for element-wise operations
  - CUDA kernel integration
  - Leverage multiple GPUs

- Use MATLAB to support CUDA development
  - Prototype and explore algorithms
  - Create test harnesses for your kernels
  - Analyze and visualize kernel results
Next steps

- Learn more by visiting www.mathworks.com/gpu

- Try GPU computing with MATLAB on Amazon EC2
  - Email matlab-gpu-trial@mathworks.com if interested

- Thank you!
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Richard Heyns, CEO of bryltyt, UK

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