Teach Parallel and Accelerated Computing with GPU Teaching Kit for Educators

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AGENDA

Introduction to NVIDIA Teaching Kits
GPU Teaching Kit for Accelerated Computing Overview
GPU Teaching Kit Contents
UIUC Activities
Other Teaching Kits in Deep Learning and Robotics
Further Q&A
BARRIERS TO TEACHING

New technology

TIME
TEACHING MATERIAL

FUNDING
TOOLS AND RESOURCES

THEORY vs APPLIED
BALANCED APPROACH

EXPERIENCE
SUPPORT
TEACHING KITS
Advancing STEM Education with Accelerated Computing

“What an amazing resource for educators in GPU computing! The GPU Teaching Kit has a wealth of resources that allow both experienced and new teachers in parallel computing easily incorporate GPUs into their current course or design an entirely new course.”
Prof. John Owens, UC-Davis

“The GPU teaching kit covers all aspects of GPU based programming.. the epitome for educators who want to float a course on heterogeneous computing using graphics processors as accelerators.”
Dr. Tajendra Singh, UCLA

“Teaching resources such as these will be invaluable in helping the next generation of scientists and engineers know how to fully harness the capability of this exciting technology.”
Dr. Alan Gray, University of Edinburgh

“The Teaching Kit covers all the needed content of a GPU/computing course.. The projects and quiz designs are handy, saving a lot of time and effort. Moreover, the whole structure is well organized to lead students step by step in CUDA programming. I highly recommend integrating it into a related syllabus.”
Dr. Bin Zhou, University of Science and Technology of China
TEACHING KITS
Breaking the Barriers to GPU Education in Academia

Co-develop with academic partners

Comprehensive teaching materials

- Lecture slides and notes
- Lecture videos
- Hands-on labs/solutions
- Larger coding projects/solutions
- Quiz/exam questions/solution

Cloud-based GPU compute resource

Software tools

Textbooks and/or e-books
Different kits for different courses

Accelerated/parallel computing
Robotics
Machine/Deep learning
Virtual Reality
Computer vision
Computer architecture
Computational domain sciences
Etc.

Russian and Portuguese translations available now, others coming soon
RELATED TEACHING KIT OFFERINGS
Collaborative Opportunities and Supporting Expertise

Instructor workshops, conferences, sponsorships and exhibits
Enablement web pages
Getting started guides/videos
Email updates
Feedback and enhancement requests
GPU Teaching Kit – Accelerated Computing

Available to Instructors Now!

developer.nvidia.com/teaching-kits
GPU Teaching Kit Module Goals
Follows 3rd Edition Textbook

Learn to program heterogeneous parallel computing systems

- High performance and energy-efficiency
- Functionality and maintainability
- Scalability across future generations

Technical subjects

- Parallel programming API, tools and techniques
- Principles and patterns of parallel algorithms
- Application case studies
- Processor architecture features and constraints

Free Electronic Copy w/Teaching Kit for Educators!

developer.nvidia.com/teaching-kits
30% discount on student copies
AC TEACHING KIT CONTENTS

Syllabus

http://syllabus.gputeachingkit.com/

Module 1: Course Introduction

In this module we review course goals and syllabus and introduce the concepts of heterogeneous and parallel programming.

Lectures and Videos

1.1 Course Introduction and Overview
- PDF Slides: Lecture-1-1-overview.pdf
- PowerPoint Slides: Lecture-1-1-overview.pptx

1.2 Introduction to Heterogeneous Parallel Computing
- PDF Slides: Lecture-1-2-heterogeneous-computing.pdf
- PowerPoint Slides: Lecture-1-2-heterogeneous-computing.pptx
AC TEACHING KIT CONTENTS

Lecture Slides

Supplement e-book chapters

Embedded audio narration

Current Release: 56 slide decks from 22 modules

.pptx and .pdf format
Module 5.1 – Thread Execution Efficiency

Warp\s and SIMD Hardware
SMs are SIMD Processors

- Control unit for instruction fetch, decode, and control is shared among multiple processing units
  - Control overhead is minimized (Module 1)
SIMD Execution Among Threads in a Warp

- All threads in a warp must execute the same instruction at any point in time
- This works efficiently if all threads follow the same control flow path
  - All if-then-else statements make the same decision
  - All loops iterate the same number of times
Control Divergence

- Control divergence occurs when threads in a warp take different control flow paths by making different control decisions
  - Some take the then-path and others take the else-path of an if-statement
  - Some threads take different number of loop iterations than others

- The execution of threads taking different paths are serialized in current GPUs
  - The control paths taken by the threads in a warp are traversed one at a time until there is no more.
  - During the execution of each path, all threads taking that path will be executed in parallel
  - The number of different paths can be large when considering nested control flow statements
AC TEACHING KIT CONTENTS

Lecture Videos

Supplement e-book chapters

Useful for “flipped” course and self-paced learning

**Current Release:** 49 videos from 22 modules

Stream individually or download as .mp4 from [http://syllabus.gputeachingkit.com](http://syllabus.gputeachingkit.com)
AC TEACHING KIT CONTENTS

Hands-on Labs/solutions

1-2 week assignments

Includes description, objectives, prerequisites and open-ended questions, and solution code templates

Latest source code and instructions always on a private Git Repository (BitBucket)

**Current Release:** 20 Labs/solutions from 22 modules

Write-ups in .pdf format
AC TEACHING KIT CONTENTS

Free AWS Educate GPU Instances

$200/instructor + $125/student per semester

Requires credit card for student accounts, non-credit card accounts eligible for less credit

Basic instructions on how to leverage for labs on Bitbucket
AC TEACHING KIT CONTENTS

Quiz questions/answers

Multiple choice, including rationale for answers

Students should be able to answer from lecture content

Current Release: 12 quiz/exam problem sets from 22 modules

.docx and .pdf formats
AC TEACHING KIT CONTENTS
Larger coding projects/solutions

3-4 week, open-ended, multidisciplinary, final semester projects

Real projects from real UIUC students

Not tied to specific modules

Current Release: 10 projects/solutions

.docx and .pdf formats

Source code solutions and .pdf write-ups included
OTHER RESOURCES

qwikLABS

Live, hands-on, self-paced learning environment to reinforce the concepts contained in the Teaching Kit

Labs include interactive instructions, coding and Q/A

Hosted in the cloud

Students only need a web-browser and internet access

Labs are timed

Free tokens with Teaching Kit
UIUC Activities

GPU Computing

UIUC ECE408/CS483
Semester calendar, 15 weeks
Uses 18 modules
Lecture slides, quizzes, labs

Coursera HPP
7 weeks
Uses 10 modules
Lecture videos, lecture slides, quizzes, labs
ECE408/CS483
Around 250 students from UIUC

ECE408/CS 508
Around 80 students for UIUC and collaborating institutions

Summer School
Around 100 students from all over the world

Coursera HPP
Around 20,000 students worldwide
WebGPU.com
A System for Online GPU Development

- An online IDE for GPU development
- Used intensively at UIUC for the past 4 years
- Essential tool for the Coursera courses offered as well as the introductory and advanced teaching courses at UIUC
- Over 15,000 registered users
- Used as a vehicle for program analysis research

Published at EduPar 2016 "WebGPU: A Scalable Online Development Platform for GPU Programming Courses" - A. Dakkak, C. Pearson and W. Hwu
Deep Learning Institute (DLI) Teaching Kit

Available free to educators!

developer.nvidia.com/teaching-kits
DLI Mission: Helping the world to solve the most challenging problems using AI and deep learning.

We help developers, data scientists and engineers to get started in training, optimizing, and deploying neural networks to solve real-world problems in diverse disciplines such as self-driving cars, healthcare, consumer services and robotics.
DLI TEACHING KIT
Available free now for educators!

– Based on Yann LeCun’s Deep Learning course at NYU

– Comprehensive teaching materials
  – Lecture slides
  – Hands-on labs/solutions
  – Quiz/exam problem sets/solutions

– GPU resources
  – Free NVIDIA DLI Qwiklab tokens for students
  – Up to $125 of Amazon Web Services (AWS) GPU instances for students per term

developer.nvidia.com/teaching-kits
Module Goals

Teach academic theory and application of DL harnessing the PyTorch and Torch frameworks

Technical subjects:

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<th>Intro to ML/DL</th>
<th>Unsupervised Learning</th>
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<td>Applied Image Classification</td>
<td>Generative Adversarial Networks</td>
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<td>Applied Object Detection</td>
<td>Optimization Techniques</td>
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<td>Convolutional NNs</td>
<td>Recurrent NNs</td>
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<td>Applied Image Segmentation</td>
<td>Natural Language Processing</td>
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<tr>
<td>Energy-based Learning</td>
<td>And more!</td>
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Robotics Teaching Kit with ‘Jet’

Available to Instructors Now!

developer.nvidia.com/teaching-kits
ROBOTICS TEACHING KIT WITH ‘JET’
Available Now Free for Educators!

- Co-developed with CalPoly University
- Comprehensive teaching materials
  - Lecture slides
  - Hands-on labs/solutions
  - Quiz/exam problem sets/solutions
  - Open-ended coding projects
- Build of Materials included
  - NVIDIA Jetson TX/TK1
  - Mechanical, chassis, electronics
  - Orderable bundles available now!
    https://www.servocity.com/tk1-jet-robot-kit
    https://www.servocity.com/tk1-jet-robot-kit

developer.nvidia.com/teaching-kits
ROBOTICS TEACHING KIT WITH ‘JET’

Module Goals

Learn interdisciplinary, GPU-accelerated, autonomous Robotics

Technical subjects

- Sensors
- Computer Vision
- Machine Learning
- Deep Learning (coming soon!)
- Dead Reckoning
- Path Planning
- Localization
- Control
- Obstacle Avoidance
Teaching Kit – Accelerated Computing

Available to Instructors Now!

aschuh@illinois.edu
developer.nvidia.com/teaching-kits
http://syllabus.gputeachingkit.com/