Robotics Teaching Kit with ‘Jet’ for Educators

Prof. John Seng (Cal Poly, SLO) and Joe Bungo (NVIDIA), GTC 2016
AGENDA

Introduction to NVIDIA’s GPU Educators Program and GPU Teaching Kits
Robotics Teaching Kit with ‘Jet’ Syllabus Overview
Introduction to ‘Jet’
Teaching Kit Contents
Cal Poly Activities, Conclusion, Q&A
GPU EDUCATORS PROGRAM
Advancing STEM Education with Accelerated Computing

“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
FLAGSHIP OFFERING: GPU 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
Possible GPU resource
Software tools
Textbooks and/or e-books
FLAGSHIP OFFERING: GPU TEACHING KITS

Breaking the Barriers to GPU Education in Academia

Different kits for different courses

- Accelerated/parallel computing
- Robotics
- Machine/Deep learning
- Computer vision
- Computer architecture
- Computational domain sciences
- Etc.
OTHER PROGRAM 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 CENTER PROGRAMS
Advancing Accelerated Computing With Academic Partnerships

**Collaboration**
23 World renowned universities collaborating with NVIDIA to advance parallel computing and its applications

**Research**
209 World-class research institutes leveraging GPU Computing & NVIDIA for breakthroughs in research

**Education**
328 Distinguished academic institutes teaching GPU Computing to students and researchers

More info at: developer.nvidia.com/academia
## GPU EDUCATORS PROGRAM VS. EDUCATION CENTERS

How do they differ?

<table>
<thead>
<tr>
<th>Support for new and existing courses</th>
<th>Recognition for <em>proven</em> and <em>established</em> courses</th>
<th>GPU Teaching Kit Access</th>
<th>Additional GPU Donations</th>
<th>Greater Discounts on HW, Events, etc.</th>
<th>Partnership PR, News Releases, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPU Education Center Program</td>
<td>Only well-established courses</td>
<td>![Star]</td>
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OTHER GTC 2016 SESSIONS
GPU Educators Program

L6113 - Teach GPU Accelerating Computing: Hands-on with NVIDIA Teaching Kit for Educators

Day: Tuesday, 04/05
Time: 13:00 - 14:30
Location: Room 210B
Robotics Teaching Kit with ‘Jet’
Available to Instructors Now!
developer.nvidia.com/educators
DEVELOPER.NVIDIA.COM/EDUCATORS
(non-member)
EDUCATORS PROGRAM REGISTRATION FORM
DEVELOPER.NVIDIA.COM/EDUCATORS
(member view)
GPU EDUCATORS PROGRAM MEMBERS AREA

NVIDIA GPU Educators Program Members Area

The NVIDIA GPU Educators Program provides free teaching materials, collaborative opportunities, and expertise to any instructor or teaching assistant interested in incorporating accelerated computing into a new or existing STEM course curriculum.

As a member of the NVIDIA GPU Educators Program you will receive the latest information on free teaching resources for instructors, our presence at academic conferences, workshops and special discounts to help you deliver world class GPU education.

Have questions or need help? Contact us - we will do whatever we can to help - Contact Us

If you requested access to the GPU Educators Kit and have been approved then you may download the file using the link below. Otherwise you will receive an "Access Denied" warning. As a faculty member or verifiable teaching assistant, you can request access by contacting us via the Educators Contact Form.

GPU Teaching Kit - Accelerated Computing Download

Robotics Teaching Kit with ‘Jet’ Download
BITBUCKET REPOSITORY FOR LABS
ROBOTICS TEACHING KIT

Module Goals

Learn interdisciplinary, GPU-accelerated, autonomous Robotics

Technical subjects

Sensors
Computer Vision
Machine Learning
Dead Reckoning
Path Planning
Localization
Control
Obstacle Avoidance
# TEACHING KIT MODULES

## Robotics with ‘Jet’

<table>
<thead>
<tr>
<th>Module 1</th>
<th>Course Introduction</th>
<th>Current Release</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>• Course Introduction and Overview</td>
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<tr>
<td></td>
<td>• Introduction to Robotics</td>
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<tr>
<td></td>
<td>• Jetson TK1/TX1 and Toolkit Basics</td>
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<tr>
<td></td>
<td>• Introduction to ‘Jet’</td>
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<tr>
<td></td>
<td>• ROS</td>
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<tr>
<td>Module 2</td>
<td>Sensors and Actuators</td>
<td>Current Release</td>
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<tr>
<td></td>
<td>• Sonar</td>
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<td></td>
<td>• Camera</td>
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<tr>
<td></td>
<td>• Accelerometer</td>
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<td></td>
<td>• Gyroscope</td>
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<tr>
<td>Module 3</td>
<td>Computer Vision</td>
<td>Current Release</td>
</tr>
<tr>
<td></td>
<td>• Introduction to Computer Vision</td>
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<tr>
<td></td>
<td>• Image Representation</td>
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<td></td>
<td>• Edge Detectors</td>
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<tr>
<td></td>
<td>• Hough Transform</td>
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<td>• Image Filtering and Moments</td>
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<tr>
<td>Module 4</td>
<td>Machine Learning</td>
<td>Future Release</td>
</tr>
<tr>
<td></td>
<td>• Machine Learning with Neural Networks</td>
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<tr>
<td></td>
<td>• Neural Networks Models</td>
<td></td>
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<tr>
<td></td>
<td>• cuDNN</td>
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<td></td>
<td>• Training and Usage</td>
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# TEACHING KIT MODULES

## Robotics with ‘Jet’

<table>
<thead>
<tr>
<th>Module 5</th>
<th>Dead Reckoning</th>
<th>Future Release</th>
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<tbody>
<tr>
<td></td>
<td>• Dead Reckoning</td>
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<td></td>
<td>• Odometry Model for Differential Drive</td>
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<table>
<thead>
<tr>
<th>Module 6</th>
<th>Path Planning</th>
<th>Future Release</th>
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<tbody>
<tr>
<td></td>
<td>• Path Planning</td>
<td></td>
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<td></td>
<td>• Wavefront Path Planning</td>
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<thead>
<tr>
<th>Module 7</th>
<th>Robot Localization</th>
<th>Future Release</th>
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<tr>
<td></td>
<td>• Robot Localization</td>
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<td></td>
<td>• Monte Carlo Localization</td>
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<td></td>
<td>• Particle Filters</td>
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<thead>
<tr>
<th>Module 8</th>
<th>Control</th>
<th>Future Release</th>
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<tr>
<td></td>
<td>• Control</td>
<td></td>
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<td></td>
<td>• PID Control</td>
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<table>
<thead>
<tr>
<th>Module 9</th>
<th>Obstacle Avoidance</th>
<th>Future Release</th>
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<tbody>
<tr>
<td></td>
<td>• Smooth Obstacle Avoidance</td>
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<tr>
<td></td>
<td>• Obstacle Avoidance and Navigation</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Module 10</th>
<th>Final Project</th>
<th>Current Release</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>• Motivation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Robot Capture the Flag Game</td>
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Robotics Teaching Kit with ‘Jet’
Available to Instructors Now!
developer.nvidia.com/educators
Jetson TX1

<table>
<thead>
<tr>
<th>Feature</th>
<th>JETSON TX1</th>
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<tbody>
<tr>
<td>GPU</td>
<td>1 TFLOP/s 256-core Maxwell</td>
</tr>
<tr>
<td>CPU</td>
<td>4x 64-bit ARM A57 CPUs</td>
</tr>
<tr>
<td>Memory</td>
<td>4 GB LPDDR4</td>
</tr>
<tr>
<td>Video decode</td>
<td>4K 60Hz H.264</td>
</tr>
<tr>
<td>Video encode</td>
<td>4K 30Hz H.264</td>
</tr>
<tr>
<td>CSI</td>
<td>Up to 6 cameras</td>
</tr>
<tr>
<td>Display</td>
<td>2x DSI, 1x eDP 1.4, 1x DP 1.2/HDMI</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>802.11 2x2 ac</td>
</tr>
<tr>
<td>Networking</td>
<td>1 Gigabit Ethernet</td>
</tr>
<tr>
<td>PCI-E</td>
<td>Gen 2 1x1 + 1x4</td>
</tr>
<tr>
<td>Storage</td>
<td>16 GB eMMC, SDIO, SATA</td>
</tr>
<tr>
<td>Other</td>
<td>3x UART, 3x SPI, 4x I2C, 4x I2S, GPIOs</td>
</tr>
<tr>
<td>Power</td>
<td>10-15W, 6.6V-19.5VDC</td>
</tr>
<tr>
<td>Size</td>
<td>50mm x 87mm</td>
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Jet chassis is constructed using Actobotics parts

These are machined metal parts with various aluminum channel, hubs, wheels, and brackets.
JET OVERVIEW

Chassis
Jet electronics consists of:

- NVIDIA Jetson TK1/TX1
- Arduino Mega
- H-bridge and motors
- 3 sonar sensors
- GY-521 accelerometer/gyroscope
- Single Webcam
- 3S (11.1V) 5000mAh LiPo battery
JET OVERVIEW
Jet runs ROS

Lecture material includes ROS introduction

Lab assignments provide starter code
JET OVERVIEW

Architecture Design

- **Jetson TK1/TX1**
- **Arduino Mega**
- **H-Bridge Shield**
- **Left Motor**
- **Right Motor**
- **Sonar Module**
- **Sonar Module**
- **Sonar Module**
- **Camera**
- **Encoder readings**
- **USB**
- **I^2C**
- **Accel/Gyro (GY-521)**
CURRENT JET BOM

Retail prices shown

Working on discounted bundle, none yet

Amazon lists:
http://amzn.com/sl/16YHGMBK62X6G (TK1)
http://amzn.com/sl/2QNJMQAAMVYRN (TX1)
Inserting video: Insert/Video/Video from File. Insert video by browsing your directory and selecting OK. File type that works best in PowerPoint is: .wmv.
Inserting video: Insert/Video/Video from File.

Insert video by browsing your directory and selecting OK.

File type that works best in PowerPoint is: .wmv
TEACHING KIT CONTENTS

Lecture Slides

Initial Release: 14 total slide decks from 4 modules

Later Release: ~30 total slide decks from 10 modules + Embedded audio narrations

.pptx format
TEACHING KIT CONTENTS

Quiz questions/answers

Multiple choice, including rationale for answers

Students should be able to answer from lecture content

Initial Release: 3 total quiz questions/answers from 4 modules

Later Release: 9 total quiz questions/answers from 10 modules

.docx and .pdf formats
TEACHING KIT CONTENTS

Hands-on Labs/solutions

1-2 week assignments
Includes description, objectives, prerequisites and open-ended questions
Includes Pseudo-code and solution code templates
Latest source code and instructions always on BitBucket
Initial Release: 5 total labs from 4 modules
Later Release: ~12 total labs from 10 modules
.docx and .pdf formats
TEACHING KIT CONTENTS

Larger coding projects/solutions

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

Not tied to specific modules

Initial Release: 1 total project/solution/report

Later Release: ~3 total projects/solutions/reports

/docx and .pdf formats

Solutions in source code
OTHER RESOURCES

qwikLABS

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

Labs includes interactive instructions, coding and Q/A

Hosted in the cloud

Students only needs a web-browser and internet access

Labs are timed

Free tokens with Teaching Kit
RELATED CAL POLY ACTIVITIES

Robotics at Cal Poly is a multi-disciplinary area

Encourage students to learn by actively engaging in projects

Students learn best by applying theory to real robot designs
Q&A
Available to Instructors Now!
developer.nvidia.com/educators