Raspberry Pi Programming using Simulink

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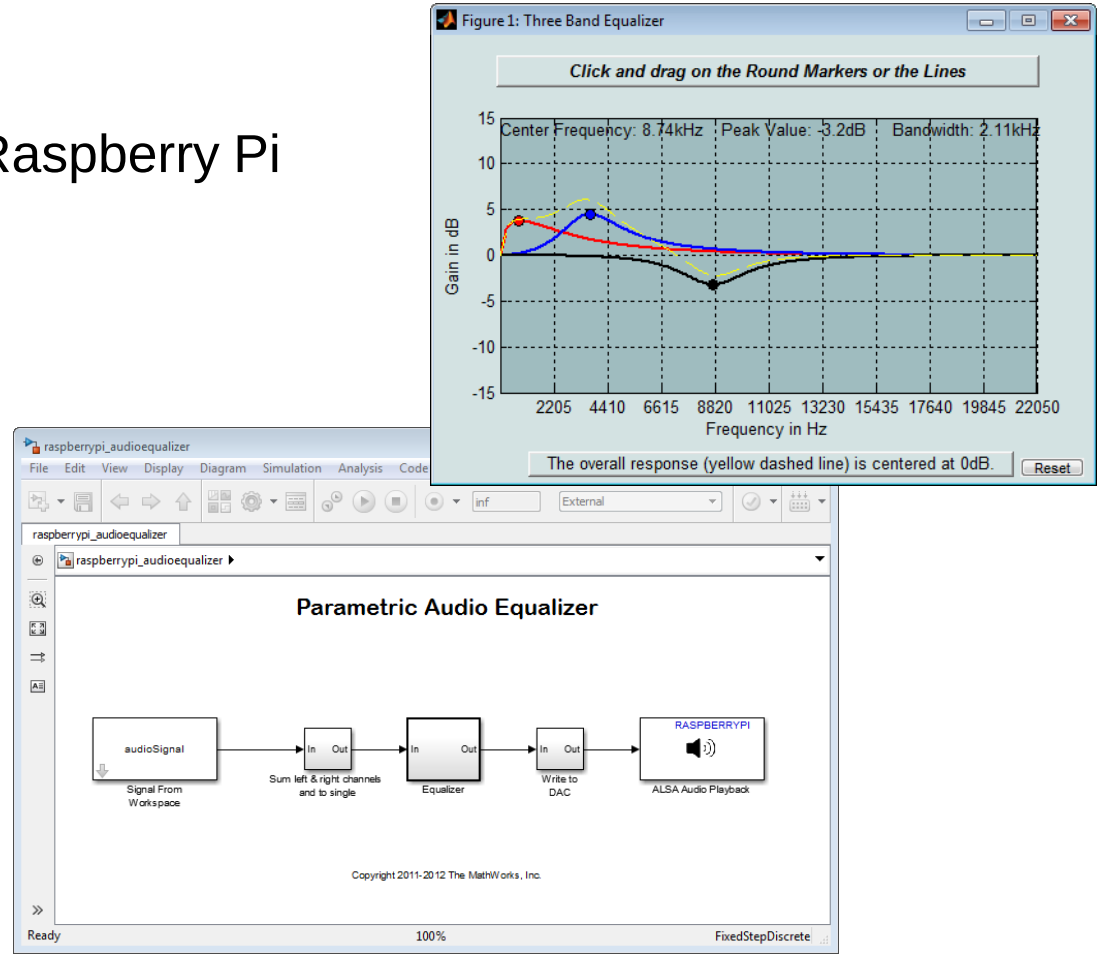
Agenda

- Introduction to Raspberry Pi
- Software Setup
  - Installation of Simulink Support Package for Raspberry Pi
- Hardware Setup
  - Test that hardware is connected and working
- Build and run model
  - Image Inversion
- Examples
  - Object detection
  - Barcode reader
- Wrap-up



Introduction to Raspberry Pi

- *What is it?*
  - Credit-card sized, low-cost, single-board computer with audio and video input/output, designed for teaching

- *Who created it?*
  - Raspberry Pi Foundation: http://www.raspberrypi.org/

- *What are the specs?*
  - Broadcom® system-on-a-chip which includes an ARM®11 processor running at 700 MHz with 512 MB RAM
  - Peripheral connectivity for stereo audio and digital video (1080p) and supports USB and Ethernet.
  - It measures 85.6mm x 56mm x 21mm, with a little overlap for the SD card and connectors. It weighs 45g.

"Overall real world performance is something like a 300MHz Pentium 2"

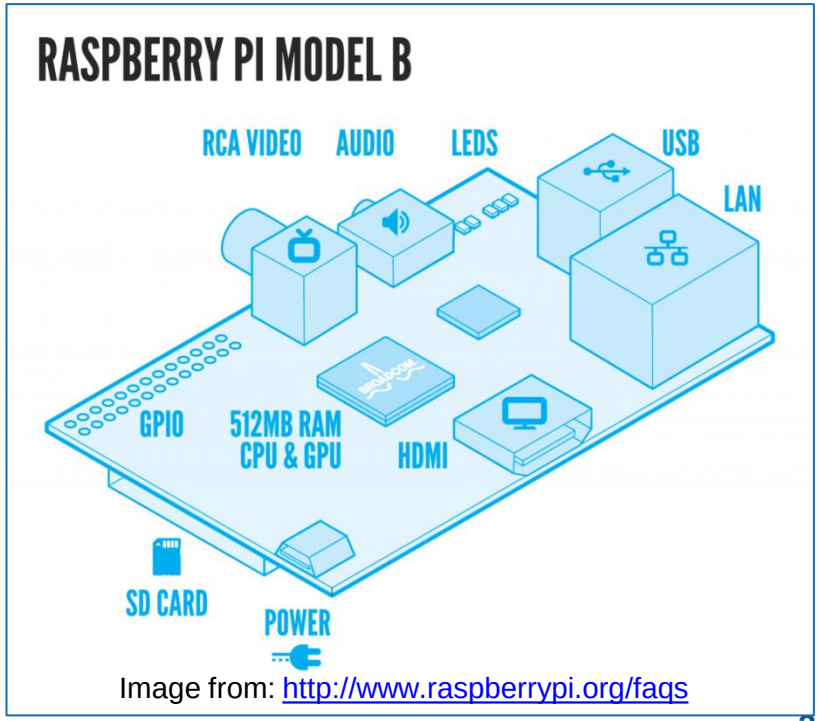


Image from: http://www.raspberrypi.org/faqs

Introduction to Raspberry Pi

- *What's the difference between Model A and Model B?*
  - Model A has 256MB RAM, one USB port and no Ethernet (network connection).
  - Model B has 512MB RAM, 2 USB ports and an Ethernet port.
  - MathWorks only supports Raspberry Pi Model B

- *How much does it cost?*
  - Approximately $35 US for the Raspberry Pi Model B
  - Cases, peripherals, and starter bundles are available

- *OK, where do I get one?*
  - Premier Farnell/Element 14 and RS Components

- *For more info: http://www.raspberrypi.org/faqs*

Software Setup

- *What software do I need?*

  - *MathWorks Software:*
    - MATLAB and Simulink (including Student Version) Release R2013a, or later

    Note: Raspberry Pi support is available on 32-bit and 64-bit Microsoft Windows only

  - *Compiler (for MathWorks software):*
    - See **Supported and Compatible Compilers**

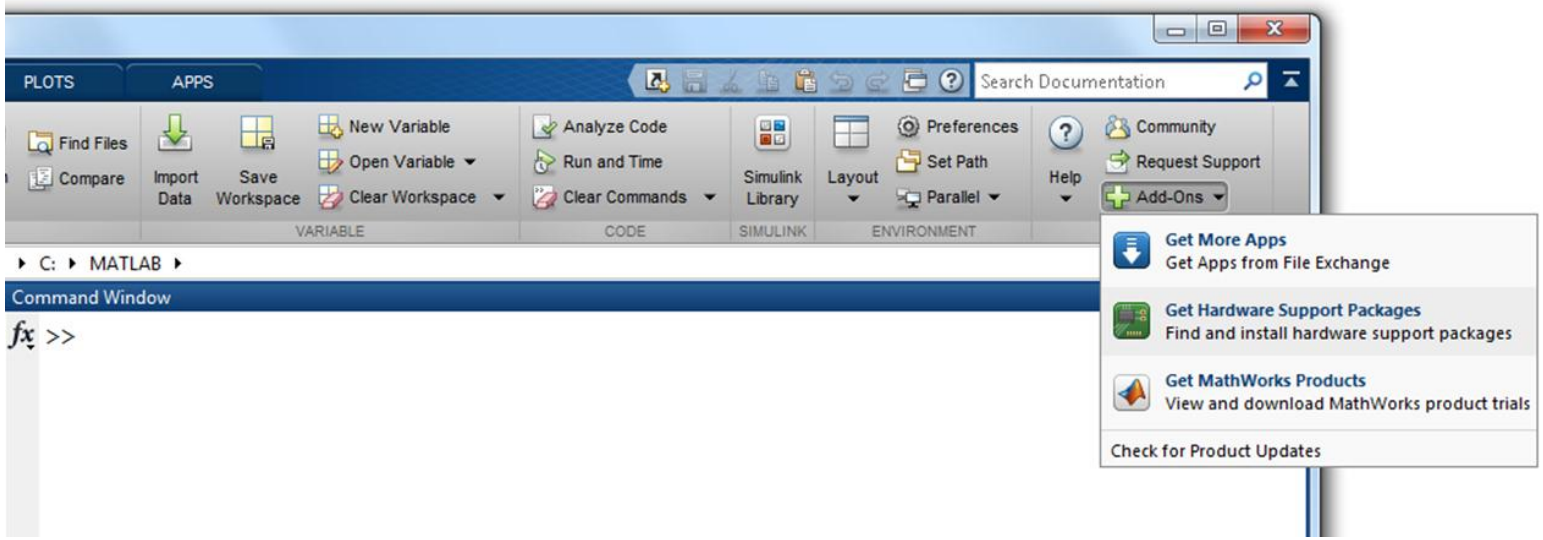
      http://www.mathworks.com/support/compilers/
    - For my 64-bit Windows 7 installation, I am using Microsoft Windows SDK 7.1 (available at no charge)

  - *Simulink Support Package for Raspberry Pi Hardware*

Simulink Support Package for Raspberry Pi Hardware

- *What is it?*
  - A set of Simulink blocks that allow you to generate programs that run on a Raspberry Pi
  - It's downloadable and it's free!

- *Where do I get it?*
  - Get from the MATLAB Toolstrip: Add-Ons → Get Hardware Support Packages

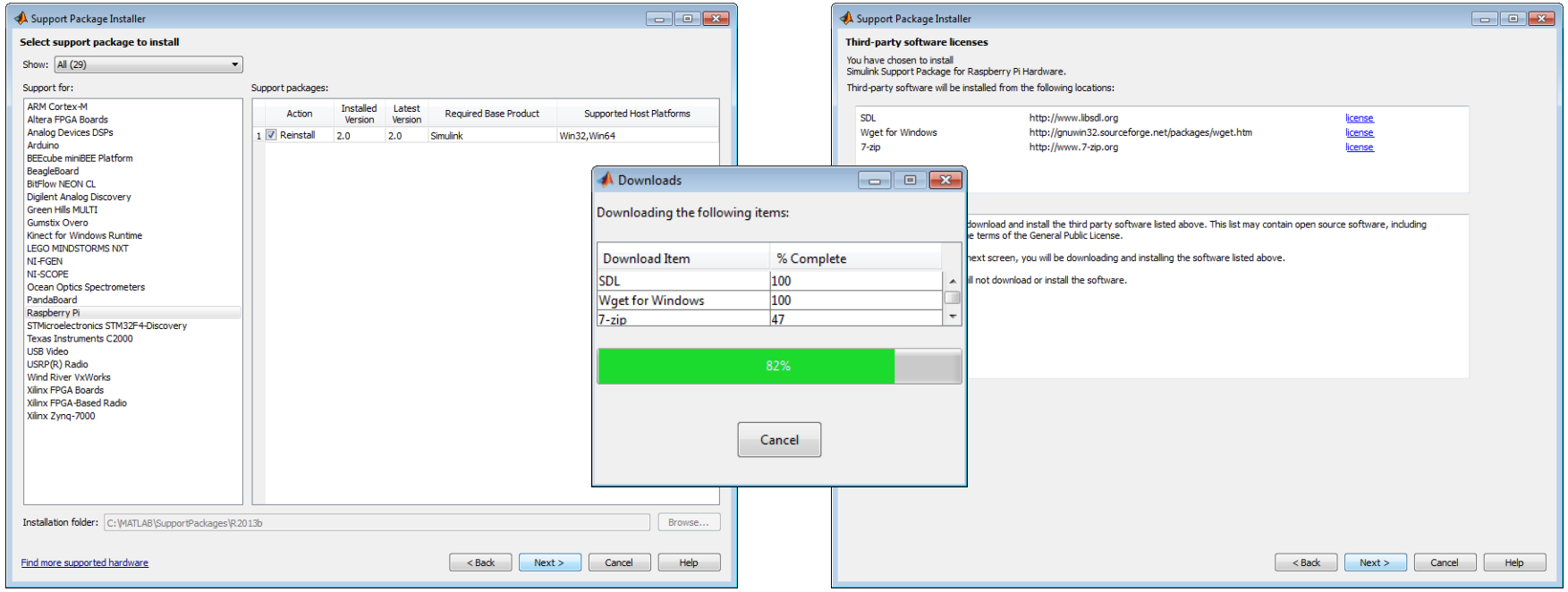


  - Get from the MATLAB Command Line: >> `targetinstaller`

Simulink Support Package for Raspberry Pi Hardware

- *Installation Process:*
  - The Support Package Installer will lead you through the installation process and install all the software you need to run on a Raspberry Pi from Simulink

Let's go get it!

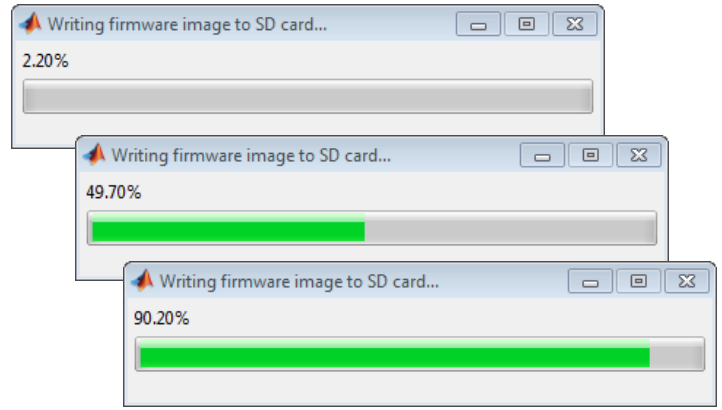


Summary: Simulink Support Package for Raspberry Pi Hardware

- Support Package Installer installs all the software elements you need to connect to and run on a Raspberry Pi

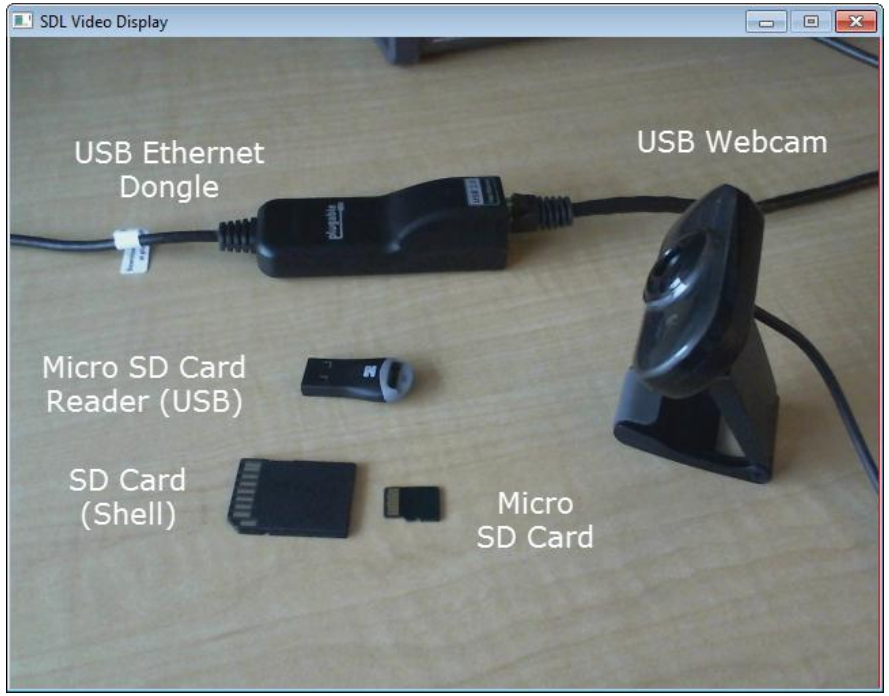
SDL	http://www.libsdl.org	license
Wget for Windows	http://gnuwin32.sourceforge.net/packages/wget.htm	license
7-zip	http://www.7-zip.org	license

- Requires MathWorks Account Login
  - (but don't worry if you don't have one, you can create one when you get to the screen)
- Firmware onto SD card
  - need to do this on the first installation



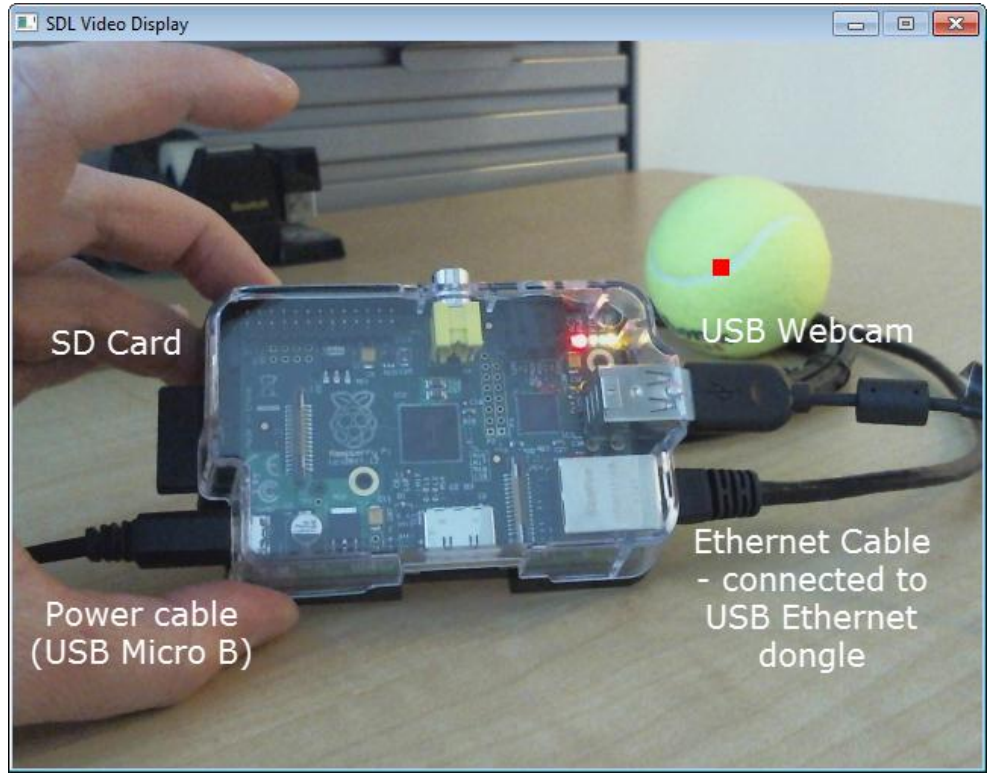
Hardware Setup

- *What hardware do I need?*
  - Raspberry Pi Model B
  - Power cable (Micro USB-B needed by Raspberry Pi)
    - Multiple options; I use USB-A to Micro USB-B cable for power
  - Ethernet cable
  - SD Card
    - MicroSD card that sockets into SD shell will also work
  - Open SD Card port (on host computer)
    - Need port to write firmware on SD Card / Micro SD card
    - Can use native port or USB-based device
  - Open Ethernet port (on host computer)
    - Option: Can use USB-Ethernet dongle
  - Case (nice to have)
  - USB Webcam (UVC compatible)



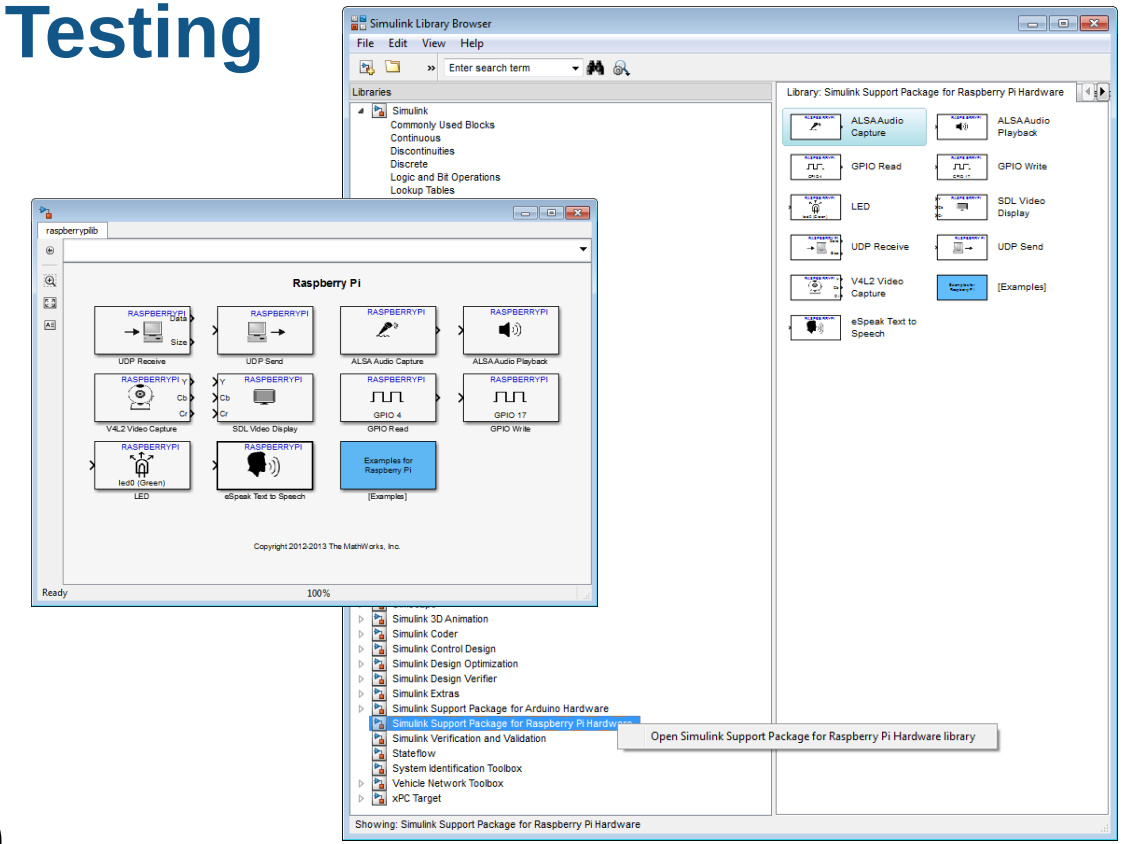
Hardware setup

- Connect Raspberry Pi
  - Plug in USB Ethernet Adapter to PC, and Ethernet cable into adapter and Raspberry Pi
  - Plug USB webcam into Raspberry Pi
  - Insert SD card (which may be a carrier for SD micro) into Raspberry Pi
  - Attach USB power cable – USB A to PC, and USB micro B to power port on Raspberry Pi
    - Wait a minute for Raspberry Pi to boot



Let's go test it!

Summary: Simulink + Raspberry Pi Testing



- Check for Support Package Installation
  - Simulink Support Package for Raspberry Pi Hardware should be in your Simulink Library
  - Can also type at MATLAB Command line:
    `raspberrypilib`

- Test your connection (PC to Raspberry Pi)
  - Type at the MATLAB command line:
    `!ping ip.add.re.ss`
  - You should see the result:

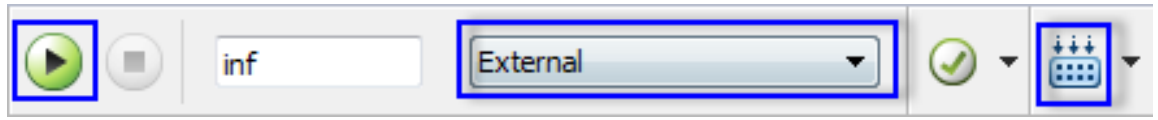
```
>> !ping 169.254.0.31

Pinging 169.254.0.31 with 32 bytes of data:
Reply from 169.254.0.31: bytes=32 time=1ms TTL=64
Reply from 169.254.0.31: bytes=32 time<1ms TTL=64
Reply from 169.254.0.31: bytes=32 time<1ms TTL=64
Reply from 169.254.0.31: bytes=32 time<1ms TTL=64

Ping statistics for 169.254.0.31:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss)
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 1ms, Average = 0ms
>>
```

Summary: Simulink + Raspberry Pi Testing (con't)

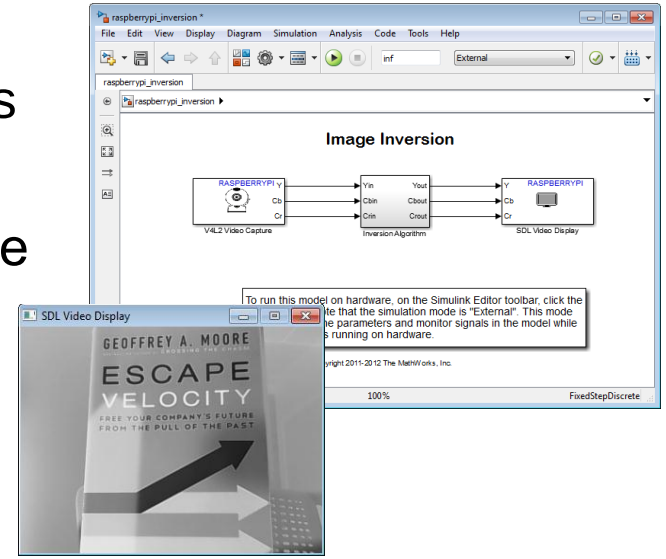
- Open Raspberry Pi Image Inversion model: `raspberrypi_inversion`

- Click Tools -> Run on Target Hardware -> Options
  - Check to make sure Target hardware = Raspberry Pi.
  - Also check the IP address.

- Click Run button



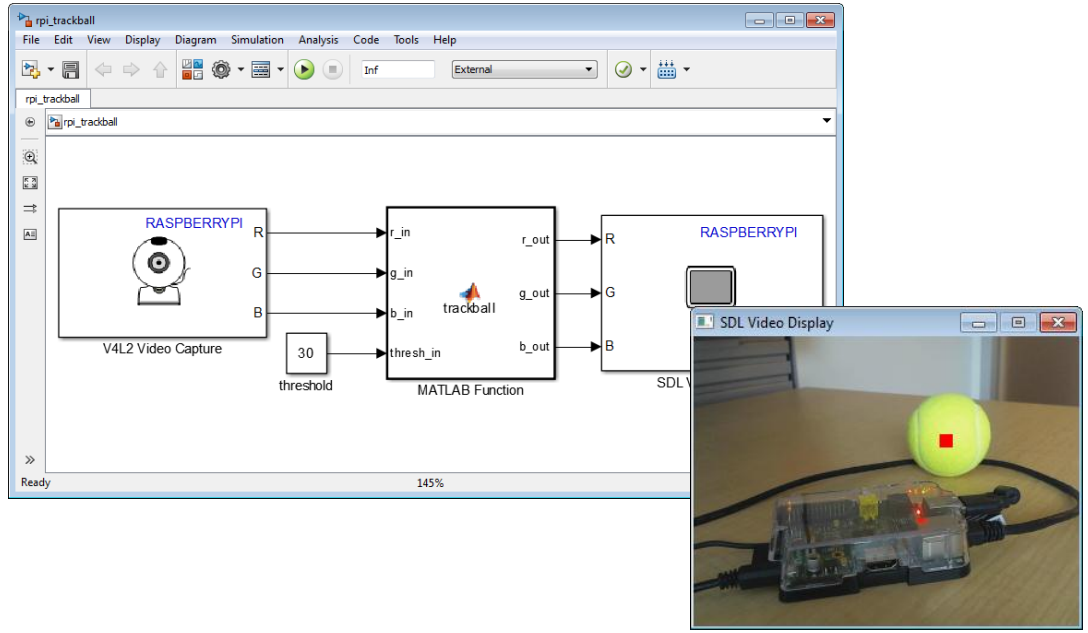
  - We used the "External" simulation mode.
  - External mode allows you to tune parameters and monitor signals in the model while the application is running on hardware
  - You can use "Deploy to Hardware" button if you want to run on the hardware with no interaction from the host



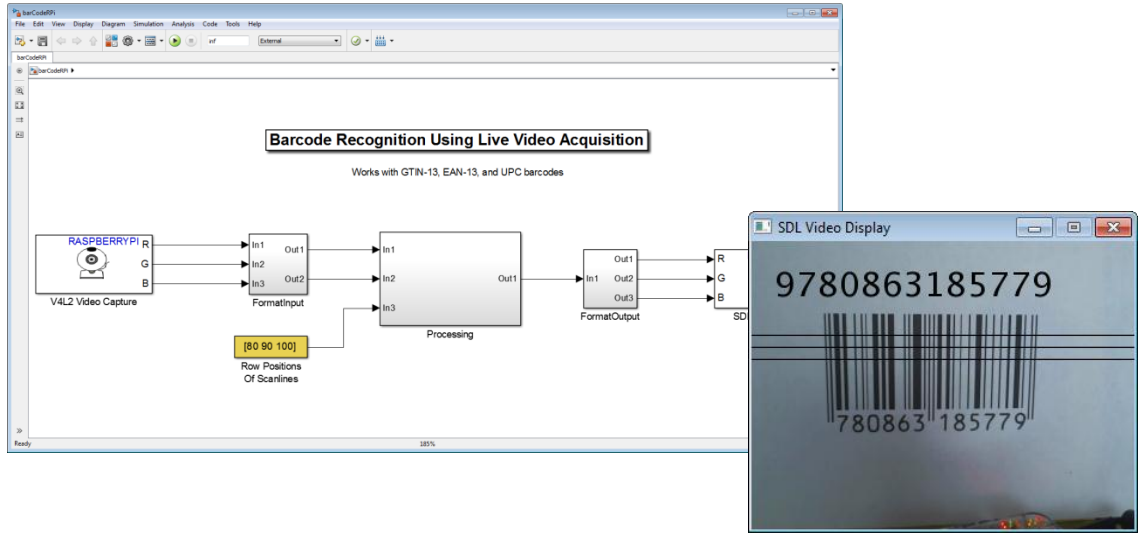
- The model is now running on the Raspberry Pi

Two Examples

- Object Detection
  - Locate and mark the center of green object

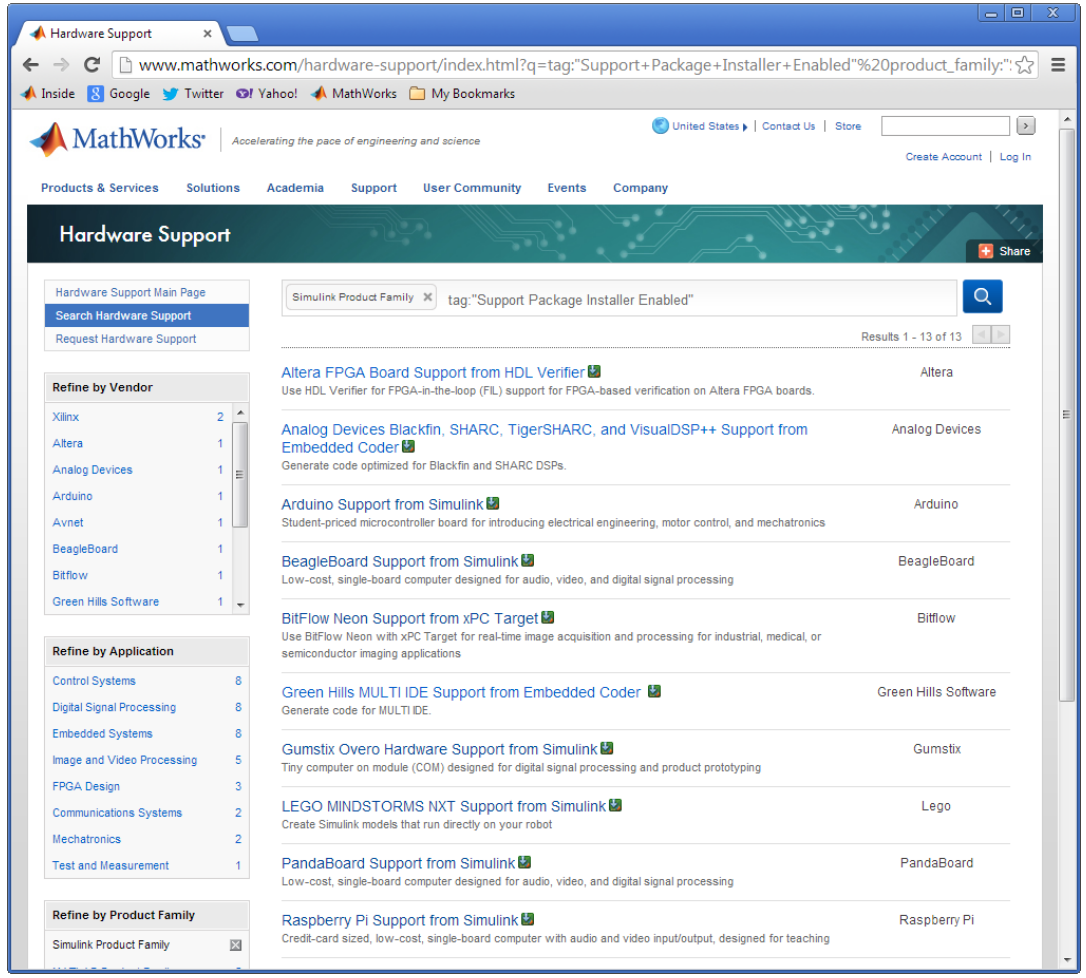


- Barcode scanner
  - Scan barcode and output numerical digits



Wrap-Up

Simulink Hardware Support



http://www.mathworks.com/hardware-support/home.html

Arduino

Lego NXT

Raspberry Pi

BeagleBoard

PandaBoard

Gumstix Overo

Selected Simulink Supported Target Hardware:

- Raspberry Pi Model B ($40)
- Arduino® Uno, Mega 2560, Nano, Ethernet Shield ($30-$70)
- LEGO® MINDSTORMS® NXT ($280)
- BeagleBoard-xM ($150)
- PandaBoard ($180)
- Gumstix® Overo hardware ($180)

Available in Student Version!

Additional Resources

www.mathworks.com/academia

www.mathworks.com/student_version