GoPynq!

Python Productivity for Zynq

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PYNQ

What is Pynq and who is it for?

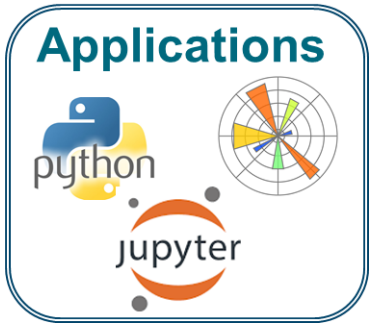
What is Pynq and who is it for?

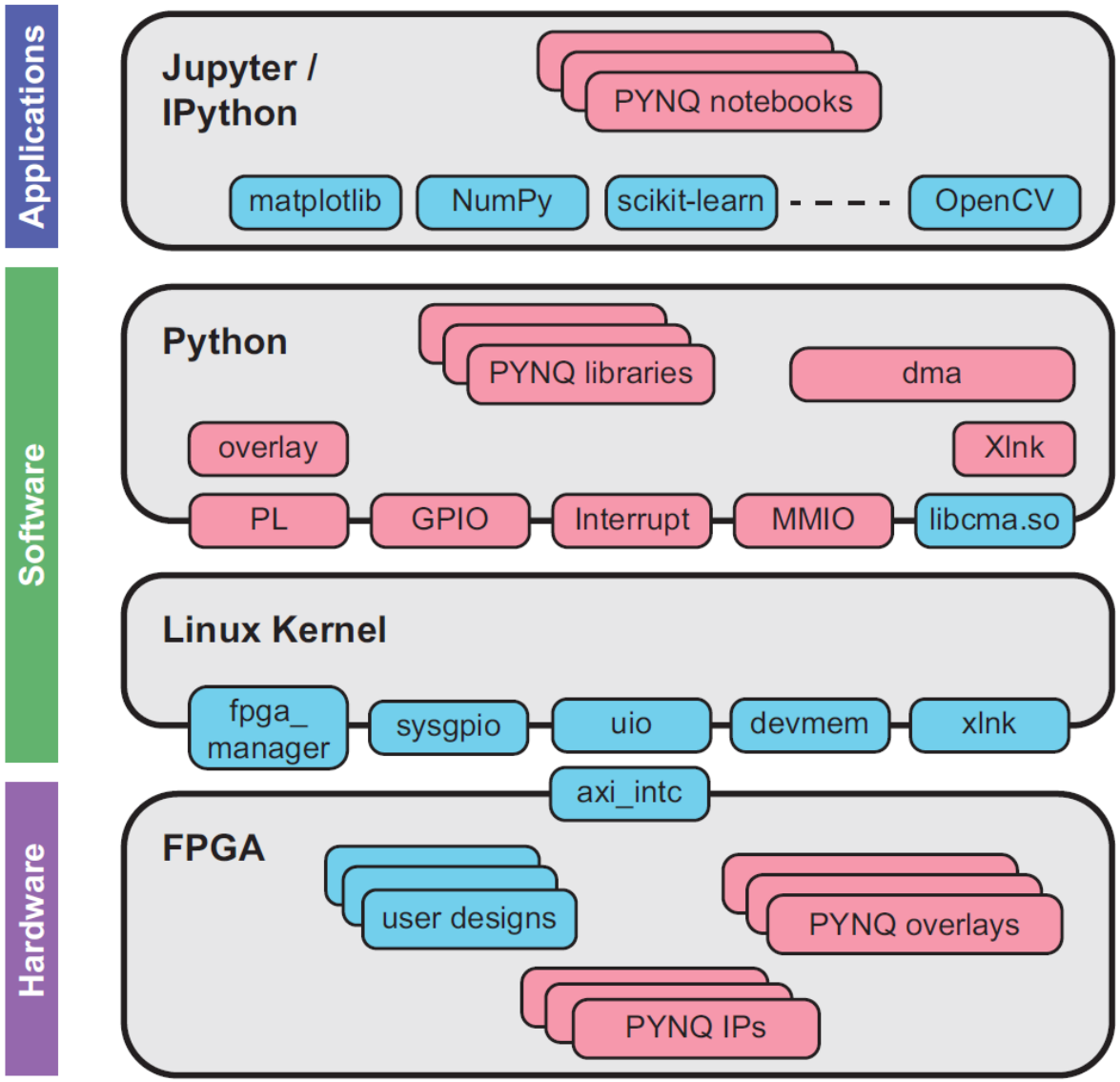
- PYNQ is an open-source framework from Xilinx® that makes it easy to design embedded systems with Xilinx Zynq® Systems on Chips (SoCs).
- Using the Python language and libraries, designers can exploit the benefits of programmable logic and microprocessors in Zynq to build more capable and exciting embedded systems.

PYNQ is intended to be used by a wide range of designers and developers including:

- Software developers who want to take advantage of the capabilities of Zynq and programmable hardware without having to use ASIC-style design tools to design hardware.
- System architects who want an easy software interface and framework for rapid prototyping and development of their Zynq design.
- Hardware designers who want their designs to be used by the widest possible audience.

PYNQ is a Framework





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Technologies used by Pynq

- **Jupyter Notebook** is a browser based interactive computing environment.

- A PYNQ enabled Zynq board can be easily programmed in Jupyter Notebook using Python.

- Using Python, developers can use hardware libraries and overlays on the programmable logic.

- The PYNQ image is a bootable Linux image and includes the pynq Python package, and other open-source packages.

PYNQ™

Jupyter Notebook Interface

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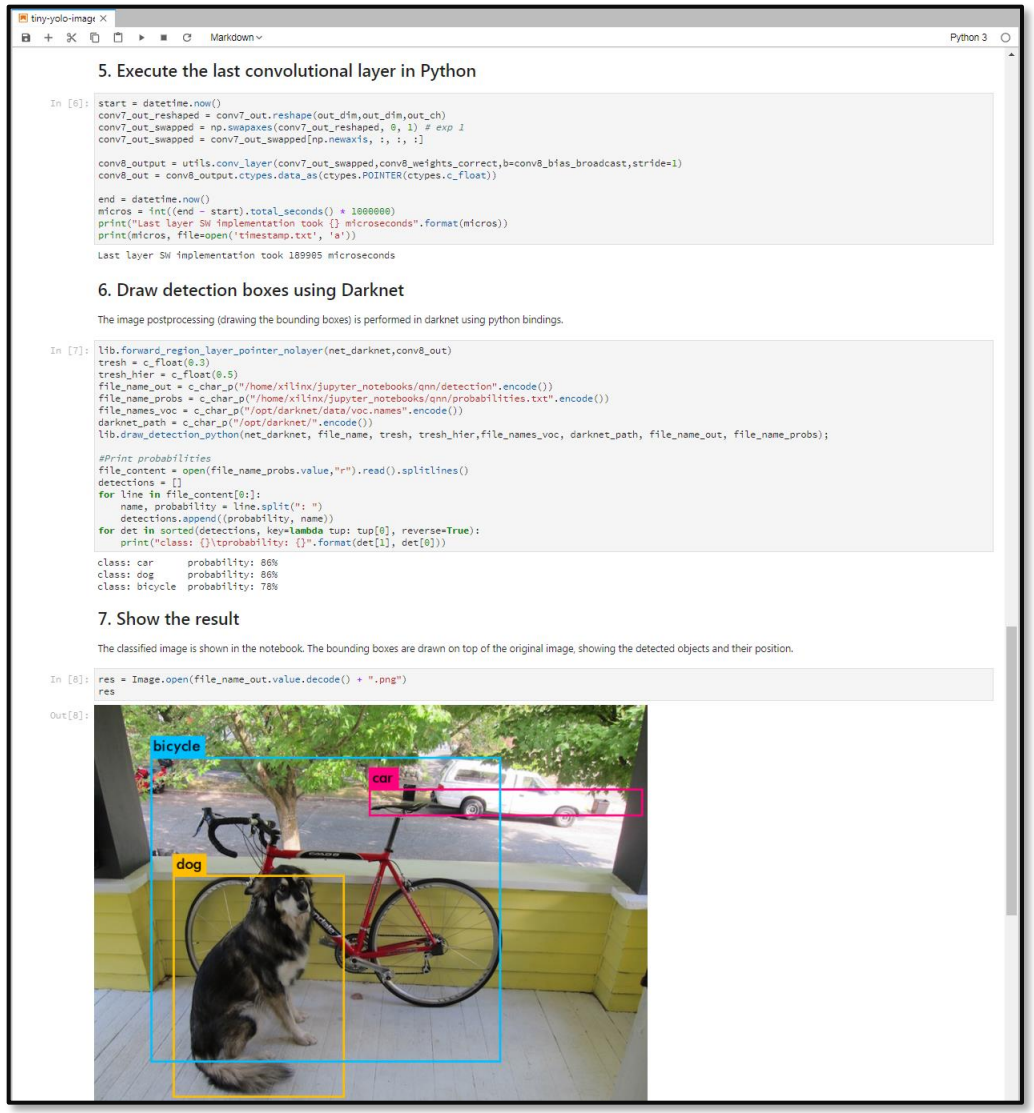
Jupyter Notebooks … the engine of data science



jupyter

Open source browser-based, executable documents

Live code, text, multimedia, graphics, equations, widgets …

1.7 million notebooks on GitHub

Taught to 1,000+ Berkeley data science students

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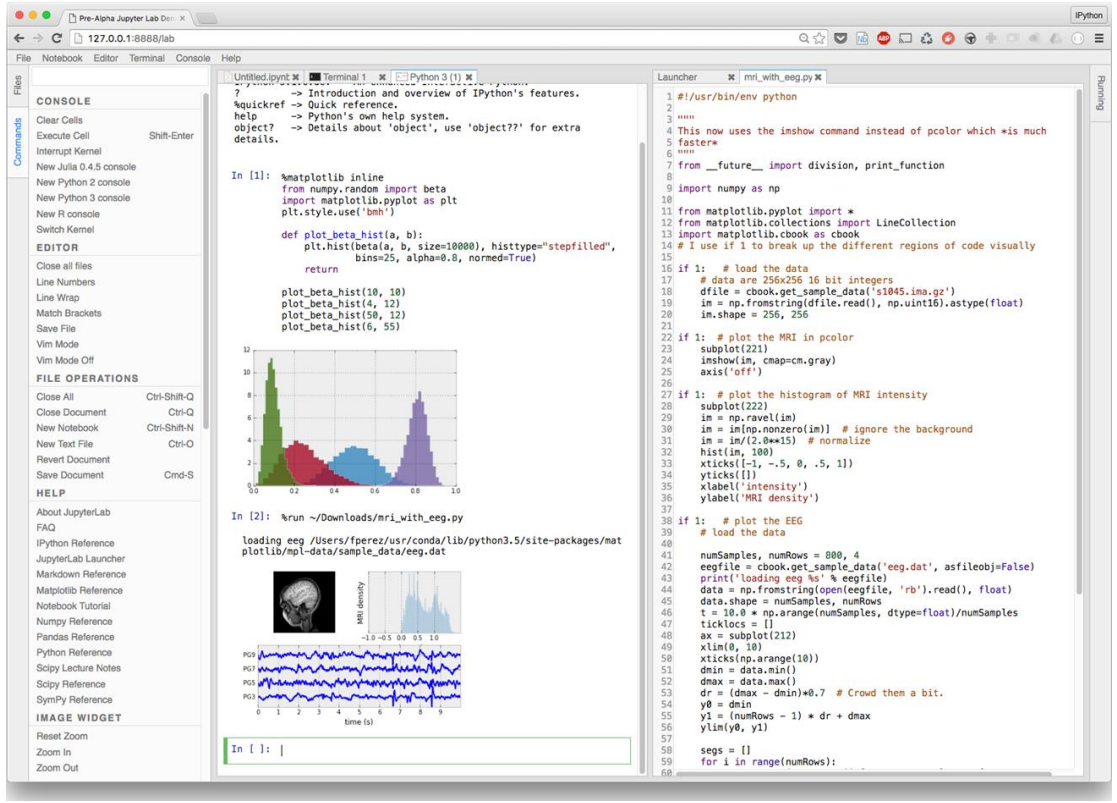
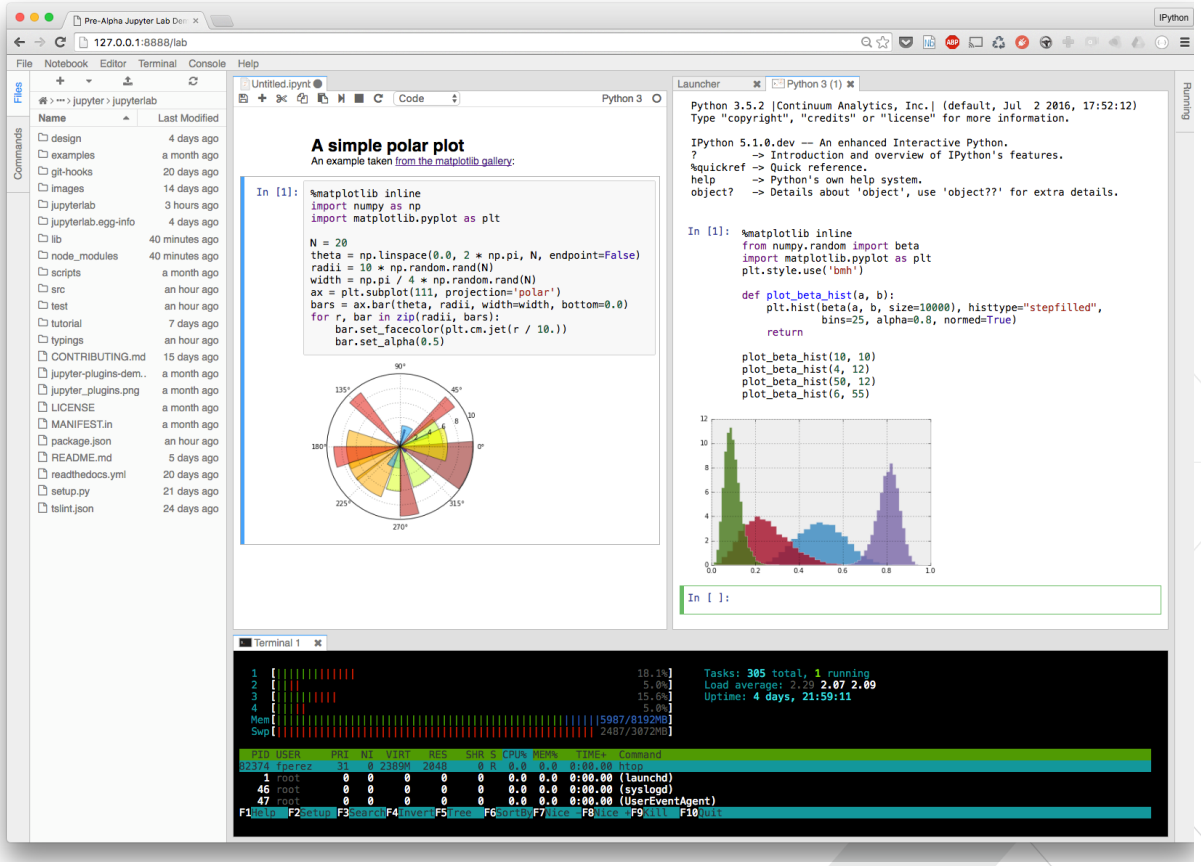
JupyterLab: web-based IDE incl. Notebooks

Add this slide





Jupyter Notebook is now one of many plug-ins within the JupyterLab integrated development environment

JupyterLab - an open-source, extensible IDE in a browser

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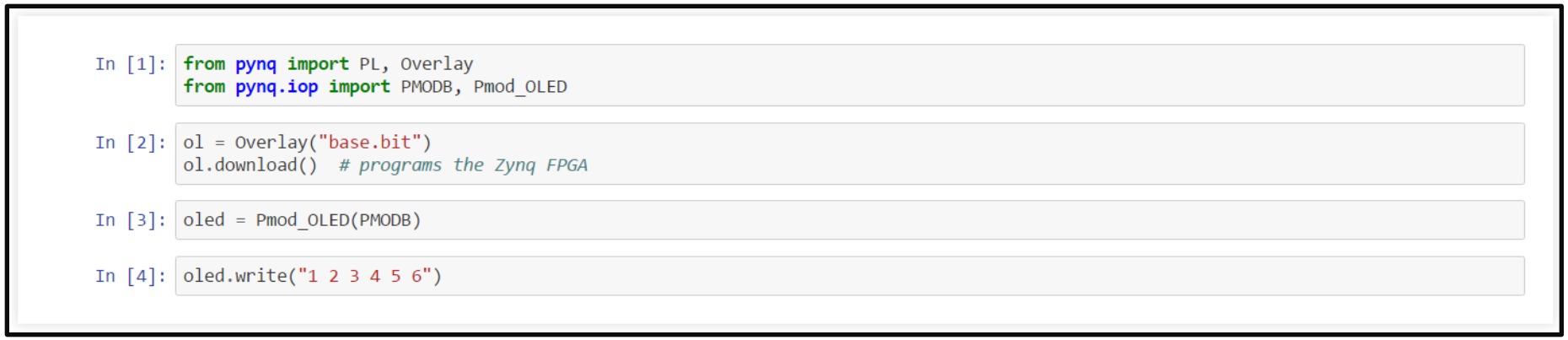
Jupyter Notebook



```
In [1]: from pynq import PL, Overlay
        from pynq.iop import PMODB, Pmod_OLED

In [2]: ol = Overlay("base.bit")
        ol.download()  # programs the Zynq FPGA

In [3]: oled = Pmod_OLED(PMODB)

In [4]: oled.write("1 2 3 4 5 6")
```

6 lines of user code … thanks to Python, FPGA overlays, abstraction & re-use

PYNQ Overlays

FPGA overlays – hardware libraries (kernels)

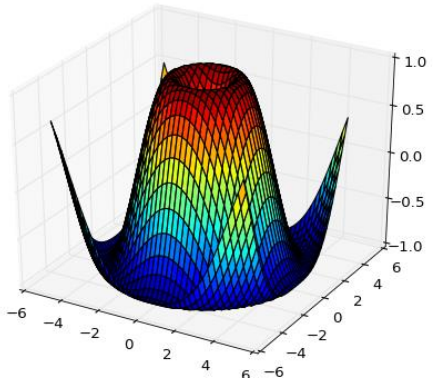
> Overlays are generic FPGA designs that target multiple users with new design abstractions and tools

- Post-bitstream programmable via software APIs
- Typically optimized for given domains
- Encourages the use of open source tools & fast compilation
- Enables productivity from re-using pre-optimized designs
- Exposes benefits of FPGAs to new users

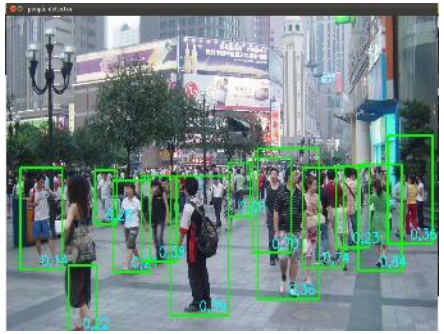
> Active research area with many papers

PYNQ Packages

Python packages for data analysis and visualisation



Matplotlib



OpenCV

- Take advantage of Python for data analysis and processing
  - NumPy
    - Scientific computing package for Python
  - Matplotlib
    - Python 2D plotting library
  - Pandas
    - Data analysis tools for Python
  - OpenCV
    - Computer Vision and machine learning software

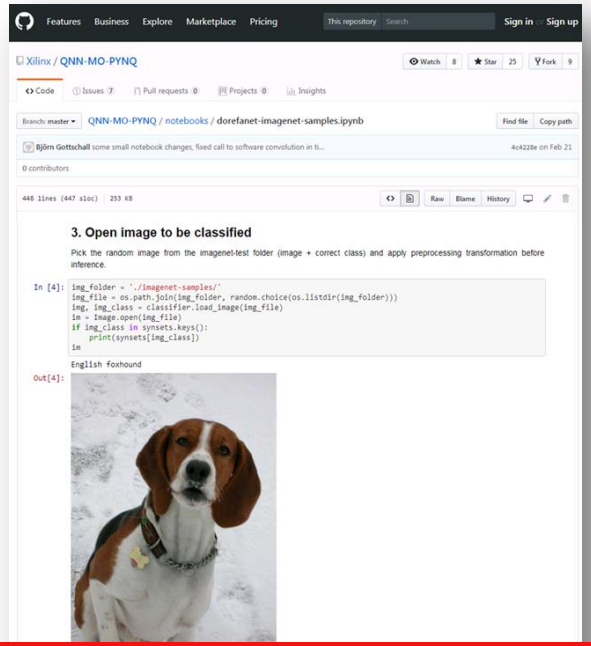
Optimized open-source software libraries ✓

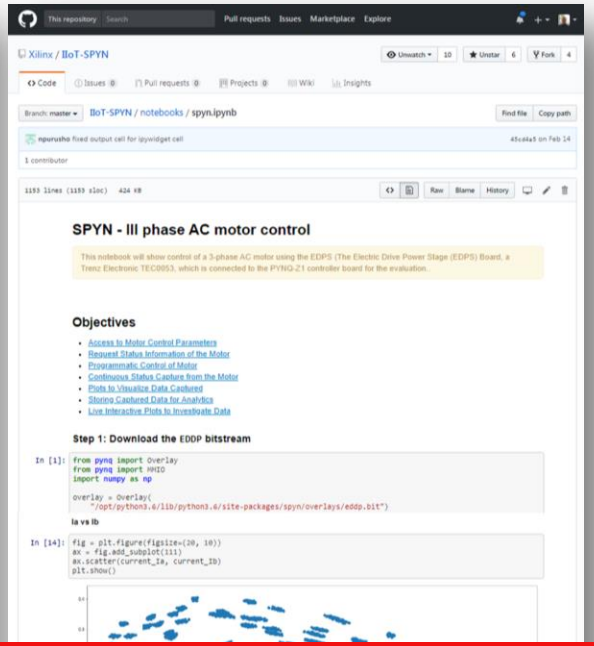
Hybrid Packages

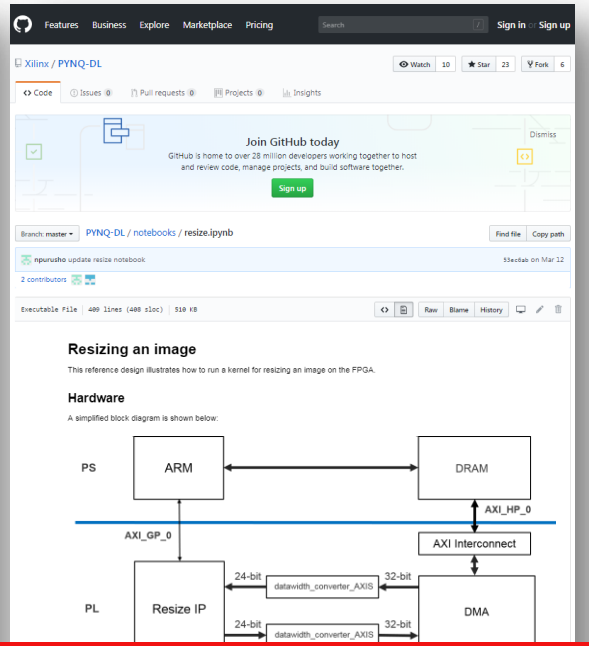
- New *hybrid packages* are created by extending Python packages with additional files:
  - Design Bitstream
  - Design metadata file
  - C drivers
  - Jupyter notebooks
- Hybrid packages enable software-style packaging and distribution of designs
- Use the Python package installer, `PIP` to install a hybrid package just like any regular Python (software only) package
  - Delivers package's files to target board
- Uses Python standard `setup.py` script for installation

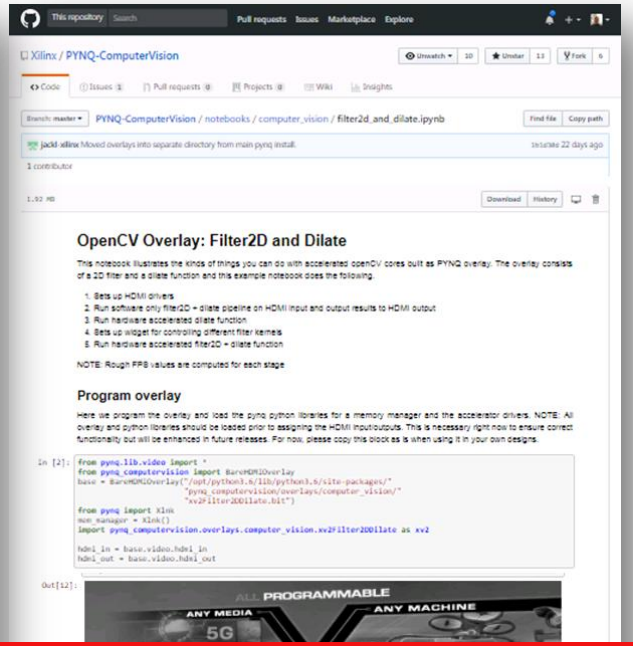
Software-style Packaging & Distribution of Designs

Enabled by new *hybrid packages*










```
Download a design from GitHub with a single Python command:

pip install git+https://github.com/Xilinx/PYNQ-DL.git
```

Benefits of PYNQ

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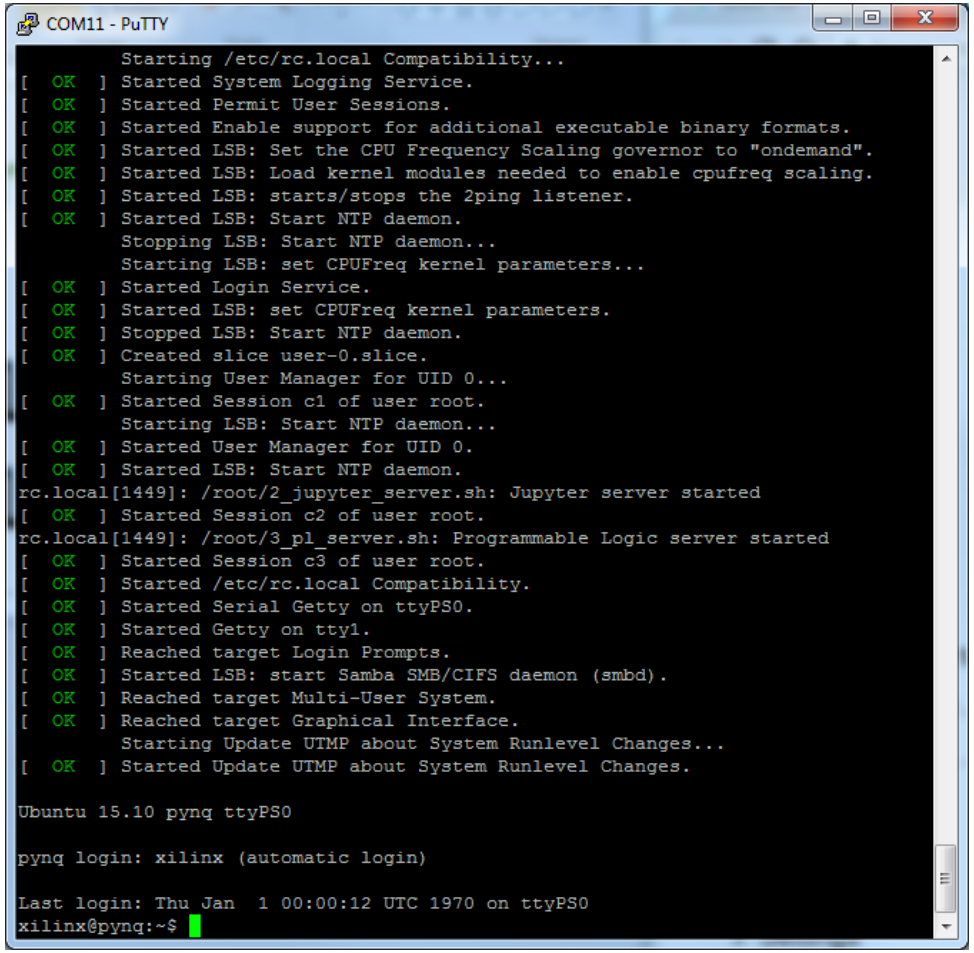
Start using PYNQ out-of-the-box



- PYNQ delivered as downloadable SD card image
  - Linux preconfigured
- Additional packages and drivers pre-installed
  - USB peripheral drivers: webcams, WiFi modules …
- PYNQ is for Zynq
  - PYNQ image is portable to other Zynq boards

Start using Zynq out of the box ✓

Desktop Linux

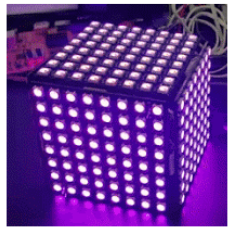
- Network/Internet access
  - “apt-get” to install packages from Ubuntu universe
  - Samba(Network drive)
  - Web services
- Git directly on board
- Compilers and other development tools
  - gcc, MicroBlaze, RISC-V ….
- Python packages
  - “pip install”
  - PYNQ Community examples on www.pynq.io

PYNQ community projects

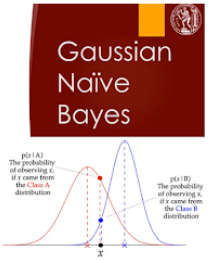
pynq.io

Ultra96 Facial Recognition Deadbolt Using PYNQ
Julian Bartolone

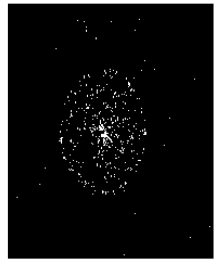
PYNQ Controlled NeoPixel LED Cube
Adam Taylor



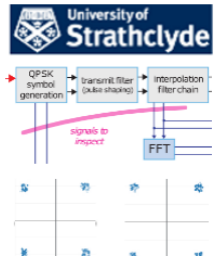
Gaussian Naive Bayes
Giorgos Tzanos, NTUA



N-Particle Gravity Simulation on Ultra96
Rajeev Patwari, Nathalie Chan King Choy

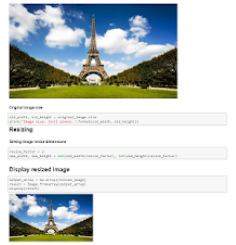


PYNQ RFSoC
University Strathclyde
QPSK demo on ZCU111



PYNQ-PRIO
BYU
Partial reconfiguration Input/Output

PYNQ Hello World
Hardware accelerated image resizer example

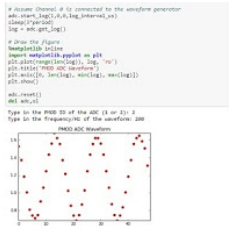


RISC-V on PYNQ
UCSD

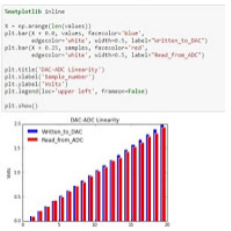
Example Notebooks

A selection of notebook examples are shown below that are included in the PYNQ image. The notebooks contain live code, and generated output from the code can be saved in the notebook. Notebooks can be viewed as webpages, or opened on a Pynq enabled board where the code cells in a notebook can be executed.

ADC waveforms

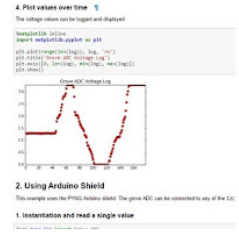


DAC ADC example



Downloading overlays

Grove ADC



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Simplified downloading bitstreams to PL

- PYNQ ‘Overlay’ class
  - Simplifies downloading bitstream
  - two lines of code
  - No Xilinx tools required
- Maintain many bitstreams on the SD card
  - E.g. multiple different demos
- Can execute Python in browser, or from command line

```
from pynq import Overlay

ol = Overlay('gray.bit')
```

Simply and fast way to configure Programmable Logic ✓

Join the Community!

pynq.io

Home | Get Started | PYNQ-Z1 Board | Community | Source Code | Support

Community Projects

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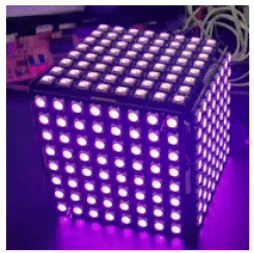

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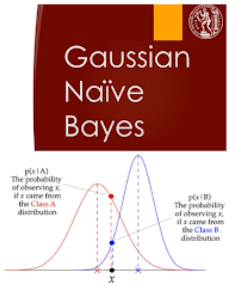

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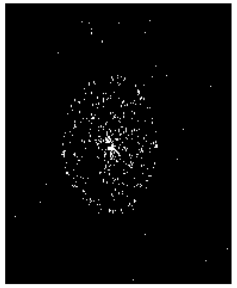

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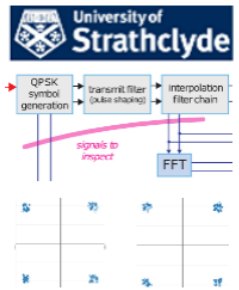

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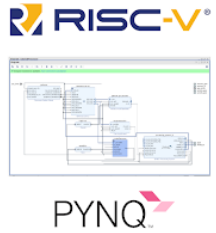

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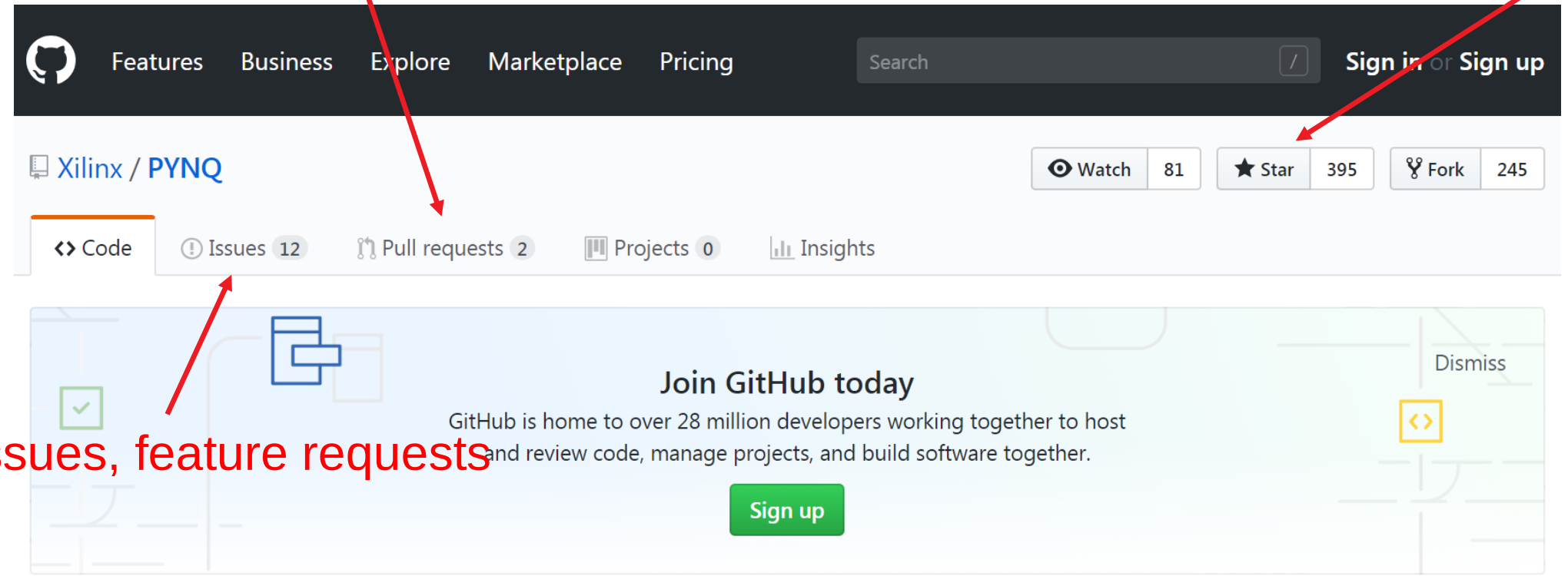
All Feedback helps

Contribute

If you like it, star it!



Issues, feature requests

Python Productivity for ZYNQ http://www.pynq.io/

pynq

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Boards for the competition

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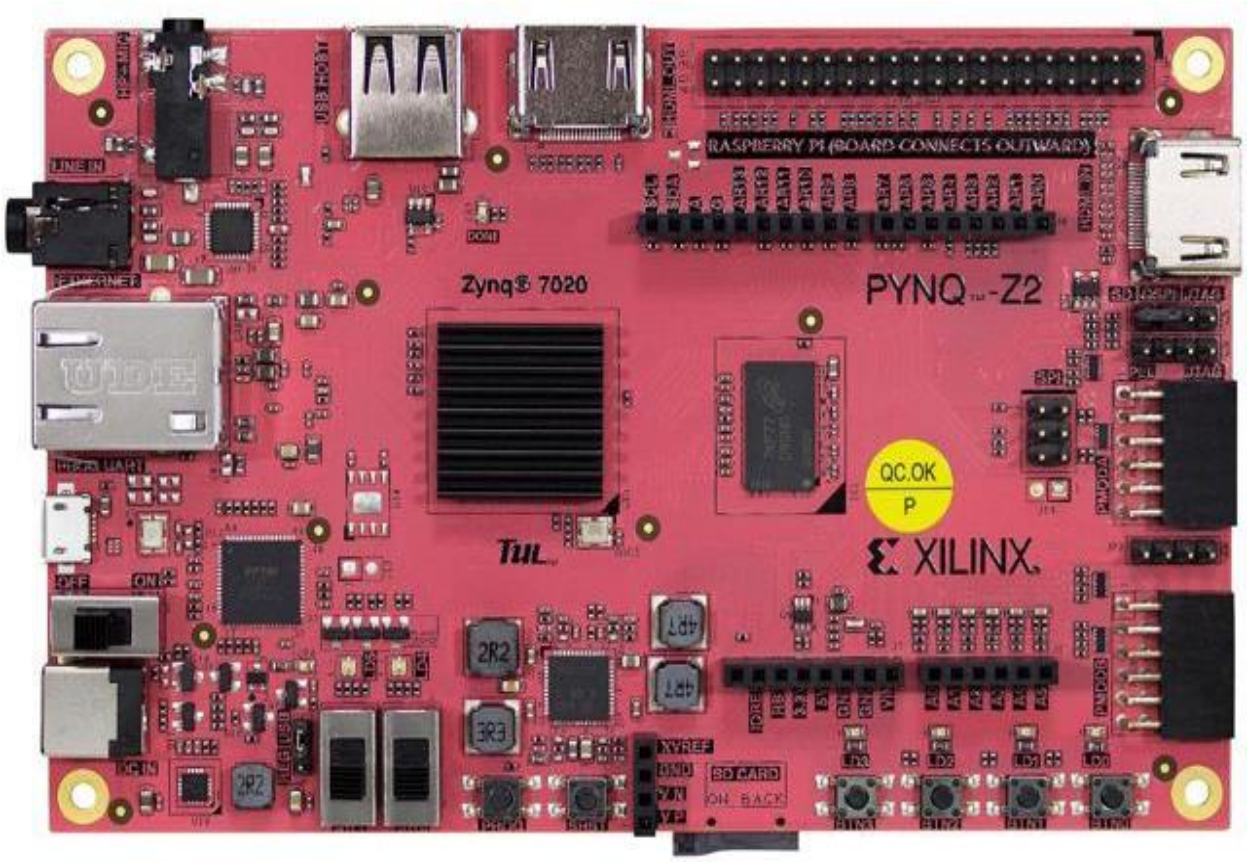
PYNQ-Z2 Board



	PYNQ-Z2
Device	Zynq Z7020
Memory	512MB DDR3
Storage	MicroSD
Video	HDMI In & Out
Audio	ADAU1761 codec with HP + Mic, Line in
Network	10/100/1000 Ethernet
Expansion	USB host (PS)
GPIO	1x Arduino Header
	2x Pmod*
	1x RaspberryPi header*
Other I/O	6x user LEDs
	4x Pushbuttons
	2x Dip switches
Dimensions	3.44” x 5.51” (87mm x 140mm)
Webpage	**TUL PYNQ-Z2 webpage**

*PYNQ-Z2 RaspberryPi header shares 8 pins with 1 Pmod

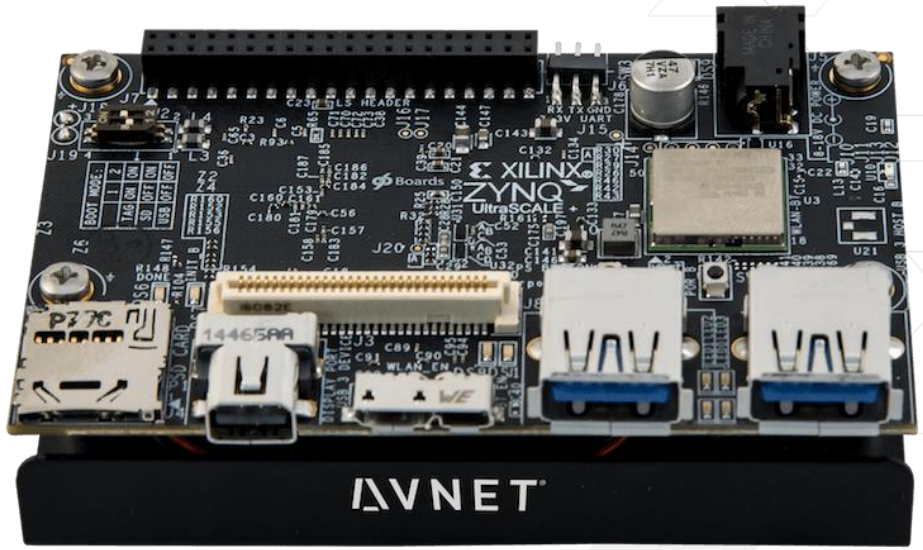
- **Pynq – Z2 board supports Pynq and numerous other I/O abilities**

Ultra96

- Ultra96 is an Arm-based, Xilinx Zynq UltraScale+ ™ MPSoC development board by Avnet based on the Linaro 96Boards Consumer Edition (CE) specification

- 96Boards is a range of hardware specifications created by Linaro to make the latest ARM-based processors available to developers at a reasonable cost.

- Supports Pynq : https://ultra96-pynq.readthedocs.io/en/latest/index.html



Ultra96 and Mezzanine

- Ultra96 can be easily paired with Mezzanine board which come with a wide variety of I/O capabilities.

- Sensor Mezzanine board (in the picture to the right) can be stacked on the Ultra96 board and a multitude of peripherals can be interfaced through it.

- LCD, touch sensor, sound sensor, rotatory angle sensor, light sensor, buzzer, temperature sensor are examples of a few sensors that can be used with the Sensor Mezzanine board.

- Visit the github page for examples and details: https://github.com/96boards/Sensor_Mezzanine_Getting_Started

Links and Documentation

- Pynq can also be used on the Ultra96 board. Here is a related video from 96Boards: https://www.youtube.com/watch?v=ptzrg9dPI3w
- This link provides more information about the Ultra96 board: http://zedboard.org/product/ultra96
- The official github page for documentation is here: https://github.com/96boards/documentation/tree/master/consumer/ultra96
- To know more about Ultra96, use 96boards website: https://www.96boards.org/product/ultra96/

Summary

PYNQ™

- PYNQ is Python productivity for Zynq
- Everything runs on Zynq, access via a browser
- Overlays are hardware libraries and enable software developers to use Zynq
- Provides a rapid prototyping framework for hardware developers

pynq.io

pynq.readthedocs.org

github.com/Xilinx/PYNQ

tul.com.tw/ProductsPYNQ-Z2.html

pynq.io/support

Adaptable.
Intelligent.