Core Deep Learning

Tiny Yolo v2.0

Polarfire Demo

User Guide

ASIC
Design Services

Contents

Real-Time Object Detection Demo: Tiny Yolo v2.0

Note

The standard configuration presented in this document does not configure the demo for Jumbo Frames, therefore the demo framerate is limited to ~25fps.

To configure the demo for Jumbo Frames see Jumbo Frames in Advanced Configuration and Usage. Given that the host PC or laptop is fast enough it is possible to achieve ~46fps using this configuration.

Introduction

The implementation was trained on Pascal Visual Object Classes (VOC)[1] dataset which can detect 20 object classes:

- person
- bird, cat, cow, dog, horse, sheep
- aeroplane, bicycle, boat, bus, car, motorbike, train
- bottle, chair, dining table, potted plant, sofa, TV/monitor

Figure: Sample output from Tiny YOLO v2.0 demo

'Tiny YOLO v2.0' demo is based on the YOLO9000 object detection system proposed by Joseph Redmon and Ali Farhadi[2] in 2016. The current implementation is optimised for performance rather than accuracy.

- Demo throughput ~46fps
- Demo throughput ~25fps without using Jumbo Frames

The demo implementation uses ping pong memory buffers to achieve maximal throughput. The next frame is uploaded to the FPGA while the current frame is processed, and the previous frame is displayed.

Requirements

- PC / Laptop running Windows 10:
  - Built-in camera (laptop) or external camera (desktop)
    Note: 'device 0' is the default video source which is the built-in camera on a laptop.
  - Ethernet port
  - Jumbo frames support on the Ethernet network adapter (Optional)
  - Flash Pro PolarFire v2.0 or later
  - WireShark v2.4.3 or later [For debug]
- RJ-45 Ethernet cross-over cable
- One of the following PolarFire kits
  - MPF300-EVAL-KIT-ES PolarFire FPGA Evaluation Kit
  - MPF300-SPLASH-KIT-ES PolarFire Splash Kit
- Objects recognized by the demo
  Use pictures or physical objects of supported classes

Demo Setup

Files and Folders

The demo contains several files and a folder that are necessary to get the demo up and running.

software	Folder	Contains the demo code used to run the demo and visualize the results.
program_flash.tcl	Tcl script	A tcl script to program the SPI.
demo_user_guide.pdf	Pdf document	User guide for the demo setup, configuration, and general information.
yolo768_t1.bin	Bin file	File that needs to be used to program the SPI flash.
yolo768_t1.stp	Staple file	Staple file to program the FPGA.

Board configuration

To run the demo on the PolarFire Evaluation Kit the following jumpers are needed.

| J23	open	Allows PolarFire to initialise from SPI Flash.
J27	short	Allow Embedded FlashPro5 to program SPI Flash.
J28	short	Use Embedded FlashPro5.
J43	short	Boosts core voltage to 1.05V.

The figure below shows the general location of the jumpers on the PolarFire Evaluation Kit.
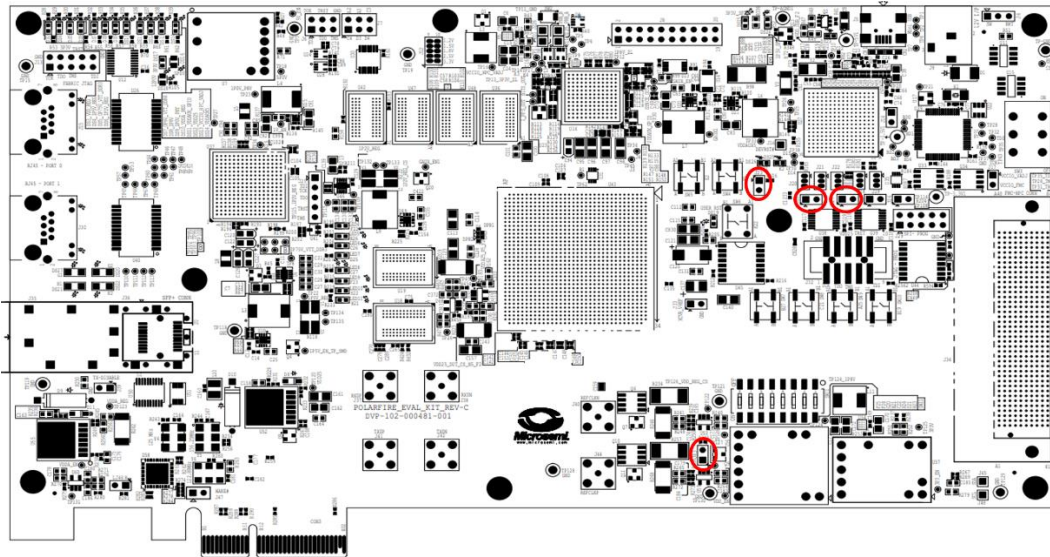
Program

The following steps need to be executed to program the FPGA and the SPI on the board.

1. Open the FlashPro app and create a new project in Single Device mode.
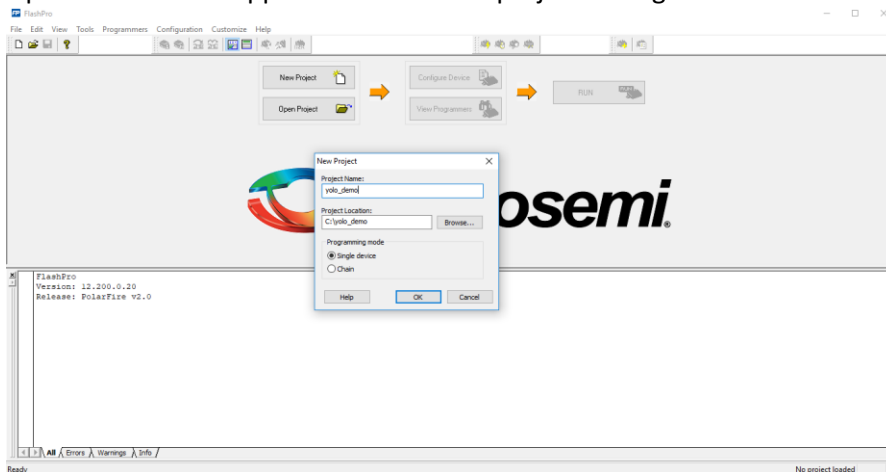
2. Ensure that the FlashPro5 programmer is enabled.

3. In the configuration tab, load the programming file and select the staple file (' yolo768_t1.stp') provided in the demo folder. Once the file is loaded program the FPGA.
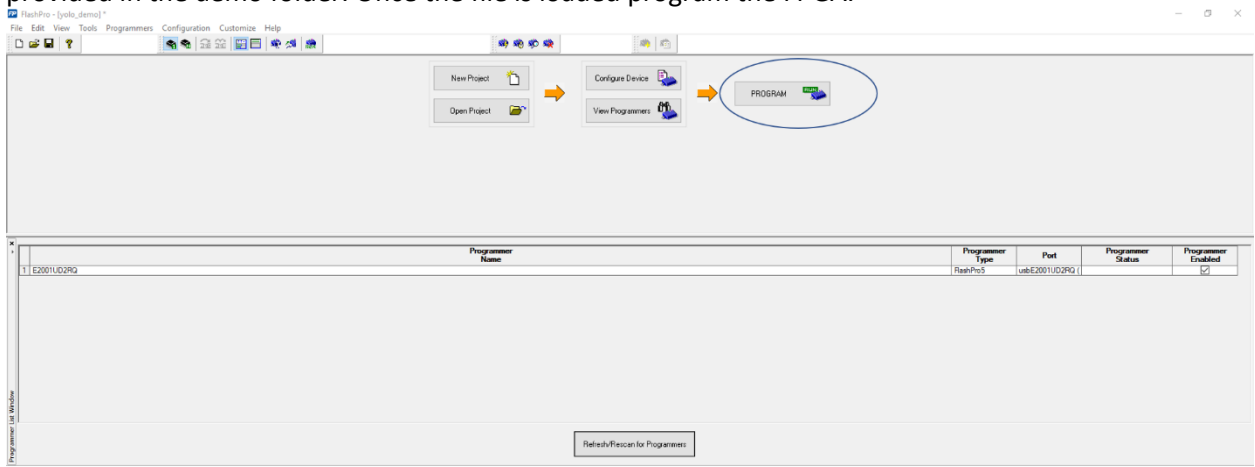

4. Open the 'program_flash.tcl' file and change the 'spi_flash_image' path to match the path where the 'yolo768_t1.bin' file resides.

```
run_selected_actions \
    -disable_prog_design {TRUE} \
    -prog_spi_flash {TRUE} \
    -spi_flash_image {R:/yolo768_t1.bin} \
    -spi_flash_action {PROGRAM_SPI_IMAGE}
```

5. In FlashPro under the file tab click on the 'Run script' option and browse for the 'program_flash.tcl' file. Once the tcl file has been selected click on 'Run' to execute the tcl script.
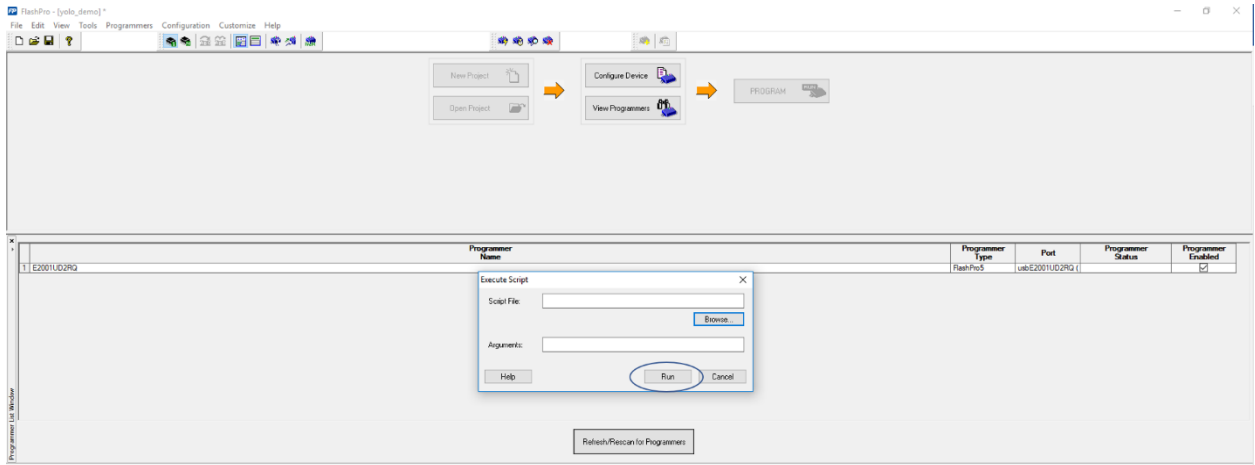
6. Connect the board directly to the Ethernet port on the PC using a cross-over cable. On the PolarFire Evaluation Kit Use the RJ45 port 0.
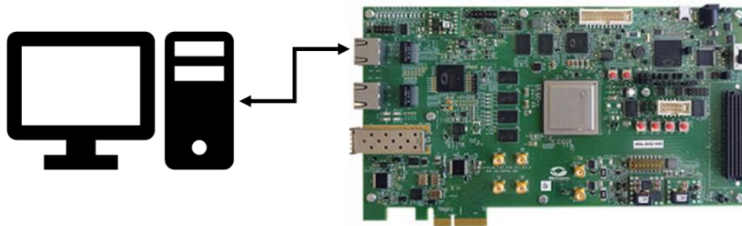

PC setup and running the demo

The following steps need to be executed to run the demo on a Windows PC. This files used in the setup can be found in the 'software' folder.

1. Follow these instructions to set up a static IP for the Ethernet network adapter.
   a. Open the 'Network and Sharing Center' available inside 'Control Panel → Network and Internet'. Click on 'Change adapter settings' to view the 'Network Connections'.
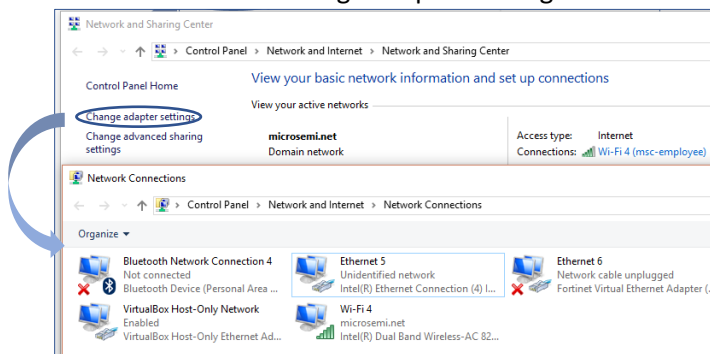
   b. Select the appropriate Ethernet connection that will be used to connect to the Polarfire Kit. Right click and open its 'Properties' window.
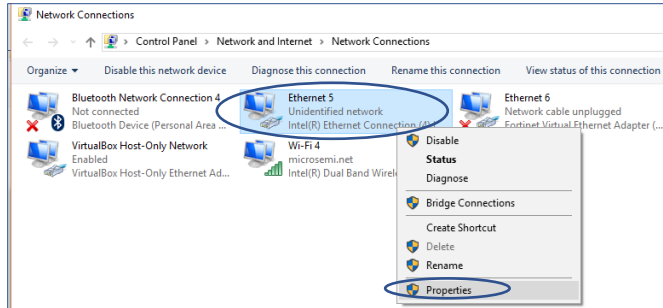
c. Scroll down to find the 'Internet Protocol Version 4 (TCP/IPv4)' property and select it.
Click on 'Properties' to assign a Static IP address.
In the 'Internet Protocol Version 4 (TCP/IPv4) Properties' window select the radio button for 'Use the following IP address'. Next enter the IP address (10.0.0.2) and Subnet mask (255.0.0.0) as shown below.
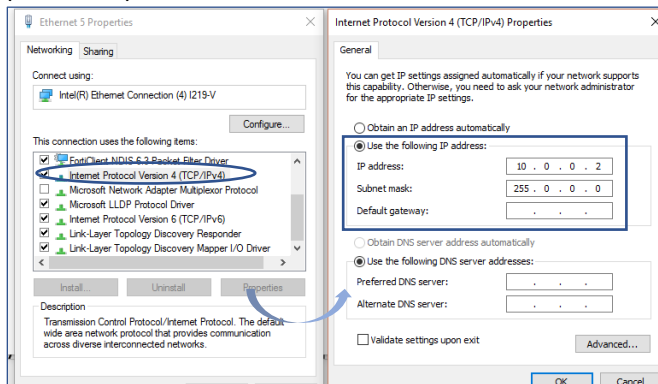
Click 'OK' to close the 'Internet Protocol Version 4 (TCP/IPv4)' window.

2. Edit the file '/configuration/demo_parameters.yaml' to provide an IP on the same subnet as the PC's Ethernet network adapter using static IP. In the example below, 10.0.0.3 wiil be used. Save the file after editing.

3. Edit '/setup/network_setup.bat' to use the same IP. Save the file after editing.

4. Run '/setup/network_setup.bat' as an Administrator. The script will add the IP address and MAC combination to the ARP table. The script also displays the ARP table, please ensure the IP address and MAC configured in step 5 appears in the table, if not, refer to the Network Routing Issues section.
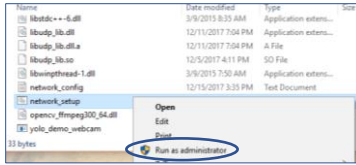
5. Run '/bin/yolo_demo_threaded.exe' to start the demo.

The demo will launch as a fullscreen window. To exist the demo press 'esc'.

Troubleshooting

Bounding boxes jump around on still images

Bounding boxes moving around intermittently in Image Glob mode is a sign of a poor network connection between the host computer and the FPGA. Small movement are expected in Capture mode in still images due to the inherent noise in the stream from the webcam.

The most probable cause is a poor network connection. If UDP link may not be able to send packets reliably through a complex network topology, therefore it is strongly recommended that a direct physical ethernet connection from the host PC to the FPGA is used.

Try lowering the "write_rate_limit" parameter in the YAML configuration file, especially if Jumbo Frames are used. See section Jumbo Frames for instructions. Note that lowering the "write_rate_limit" may decrease the framerate.

Network Routing Issues

Use the following commands to ensure that the Ethernet connection is up and running.

Static IP Address

Use `ipconfig` to confirm that the static IP address assignment is successful.

Physical Address

Use `arp -a` to confirm that the physical address assignment is successful (network_setup.bat).

If the physical address assignment was unsuccessful, restart the computer with the ethernet cable connected to both the computer and FPGA board and rerun '/setup/network_setup.bat' as an Administrator.

Wireshark Output

Wireshark monitor should indicate a continuous flow of packets when the demo is running. Use 'ip.addr' to filter the appropriate IP.
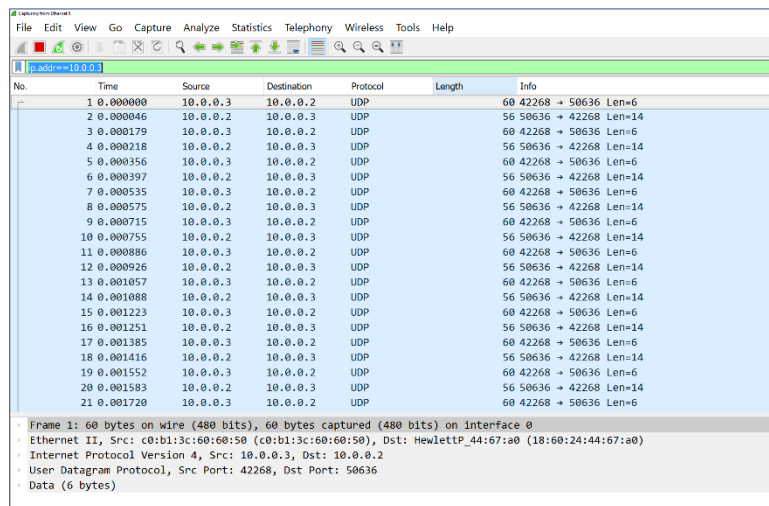
Miscellaneous

If you have issues with the Ethernet link check the following:

- Cable is securely attached to both the PC and the demo kit.
- LEDs (100MBPS, 1GMBPS LINK) between the Marvell PHY and the FPGA are lit and blinking.
- When reconnecting the cable:
  - Power cycle the board
  - Rerun '/exec/network_setup.bat' as an Administrator.

Advanced Configuration and Usage

Jumbo Frames

The demo framerate can be increased through the use of Jumbo Frames in the ethernet interface. The network throughput can safely be increased when jumbo frames are used.

1. Follow these instructions to set up Jumbo for the Ethernet network adapter.
   a. Open the 'Network and Sharing Center' available inside 'Control Panel → Network and Internet'. Click on 'Change adapter settings' to view the 'Network Connections'.
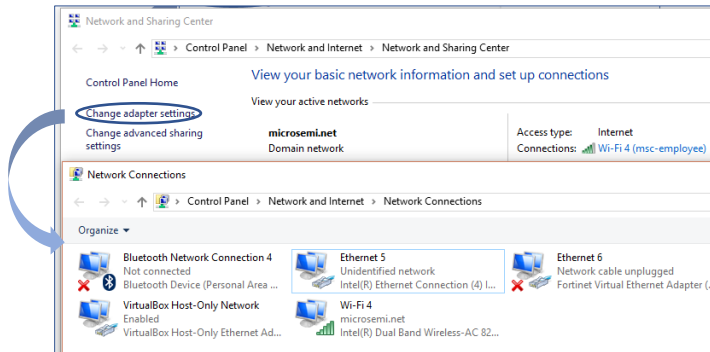
   b. Select the appropriate Ethernet connection that are used to connect to the Polarfire Kit. Right click and open its 'Properties' window.
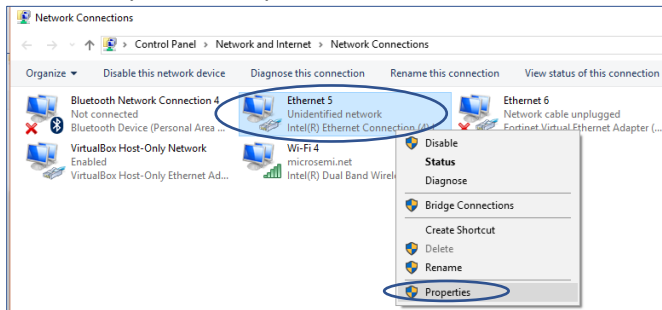
   c. In the 'Ethernet connection Properties' window click 'Configure…' to open the Ethernet network adapter's 'Properties' window. Navigate to the 'Advanced' tab and scroll down to find the 'Jumbo Packet' option. Then set it to a large value as shown.
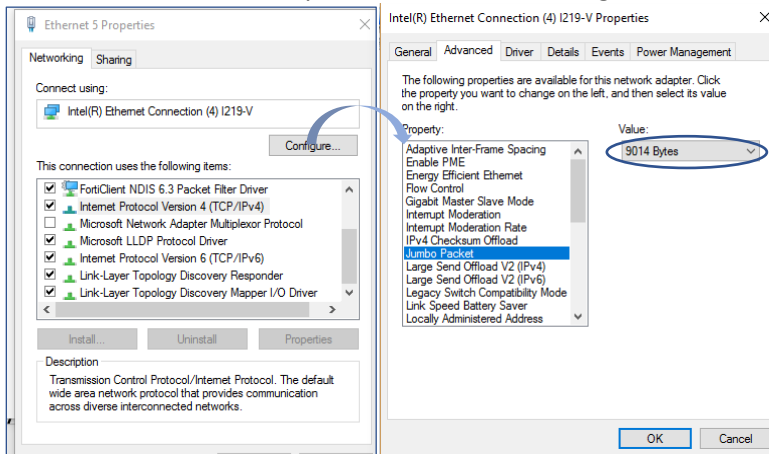
Click 'OK' to close the Ethernet network adapter's 'Properties' window. Also, close the Ethernet connection's 'Properties' window.

2. The YAML configuration file needs to be informed of the change. Open the configuration file at "/configuration/demo_parameters_windows.yaml" and navigate to the "NetworkConfiguration" section. Set the "packet_size" and "write_rate_limit" according to table.

```
"NetworkConfiguration": {
  # ip_address - IP of development board
  "ip_address":  "10.0.0.3",
  # udp_port - Port of communication protocol
  "udp_port": 42268,
  # packet size
  "packet_size": 1416,     # Maximum size without changing the adaptors MTU
  #  Maximum write speed of the input in MBps
  "write_rate_limit": 24,     # Fine with 1464 packet size, increase with la
},
}
```

Jumbo Frame Size	packet_size	write_rate_limit
1500 (default/jumbo frames disabled)	1440	29
>= 4K	4032	43

Image Glob

The input data can be changed from the standard camera feed to an image directory. Supported image formats include: bmp, jp2, jpeg, jpg, jpe, pbm, pgm, png, ppm, sr, tif, tiff.

This mode uses all images in the root of the specified directory as input. Images are processed alphabetically.

The recommended dataset for this demo is the Pascal VOC 2007 training and validation data, Pascal VOC 2012 training and validation data and the Pascal VOC 2007 test data.

Before proceeding, backup the file "/configuration /demo_parameters.yaml". The image glob mode can be selected and specified by modifying the configuration file as follows:

1. Change the 'data_source' field from "CAPTURE" to "IMAGE". Note that the parameter must be enclosed in double parenthesis as in the image below.

```
22        #   CAPTURE - Video feed from the camera with id capture_source
23        "data_source": "IMAGE",
24        "path_video": "",
```

2. Specify the path the image folder in the `path_image_glob` field. Note that folders must be separated using either "\\" or "/".

```
27        "path_image_folder": "",
28        "path_image_glob": "D:/TEMP_DATA/JPEGImages/",
29        "image_extension": "jpg",
30        "capture_source": 0,
```

3. Specify the extension of the image under the `image_extension` field.

```
27        "path_image_folder": "",
28        "path_image_glob": "D:/TEMP_DATA/JPEGImages/",
29        "image_extension": "jpg",
30        "capture_source": 0,
```

4. Start the demo as instructed under step 6 in PC setup and running the demo.

Additional configuration options in Image Glob mode include

Table 1: Additional configuration options for Image Glob mode in demo_parameters_windows.yaml

DemoConfiguration::displaytime_image	Number of milliseconds to display each image before moving onto the next image

The image source can be controlled through the following keyboard controls

Table 2: Keyboard controls for the Image Glob mode

Left Arrow	Display previous image
Right Arrow	Display next image
Space Bar	Switch to camera input source if possible

Camera Settings

If the PC or laptop has two or more cameras connected the camera can be changed by changing the "capture_source" field in the configuration file. On a laptop the built-in webcam id is '0' by default. To select an external camera change the id to '1' as shown below.

```
29        "image_extension": "jpg",
30        "capture_source": 1,
31    },
```

Additional configuration options in Capture mode include

Table 3: Additional configuration options for Capture mode in demo_parameters_windows.yaml

DemoConfiguration::capture_flip	Set to true to flip the input image horizontally. Some camera and driver combinations provide a mirrored image, this option can be used to rectify such cases.

The capture source can be controlled through the following keyboard controls

Table 4: Keyboard controls for the Capture mode

Space Bar	Switch to image glob input source if possible

Output Filtering

During execution of the YOLO demo the current confidence threshold (top) and overlap threshold (bottom) is shown in the top right of the screen.

The confidence threshold is a percentage between 0 and 100 that represents the minimum confidence of candidate bounding boxes. Low values may cause the demo to show many false positives while high values will create a very strict detector.

The confidence threshold can be decreased and increased using the 'q' and 'w' keys respectively.

The overlap threshold is a percentage representing the inverse of the maximum overlap between bounding boxes. Low values allow bounding boxes with high overlap to be retained while high values only allow bounding boxes with low overlap, e.g. 0% allows bounding boxes that is completely inside other bounding boxes while 100% requires that there is no separation between bounding boxes.

The overlap threshold can be decreased and increased using the 'a' and 's' keys respectively.

References

1. M. Everingham et al: The PASCAL Visual Object Classes Challenge: A Retrospective, 2014.
2. J. Redmon et al: YOLO9000: Better, Faster, Stronger, 2016.

Revision History

Version	Date	Author	Comments
1.0	12/26/2017	Vishakh	First draft

1.1	01/02/2018	Vishakh	Updated Introduction, Requirements, Demo Setup Added Debug Tips
1.2	01/08/2018	Hardus	Updated Demo Throughput, Demo Working Model, Updated Instruction for YAML configuration file, Describe Video File Mode and Image Glob
1.3	01/09/2018	Robert	Add clock speeds and utilization section
1.4	07/24/2018	Hardus	Change to Polarfire demo, move Jumbo Frames to Advanced Configuration, update image for new demo interface, Add keyboard commands to relevant sections
1.5	08/06/2018	Robert	Update hardware configuration and demo setup sections
1.6	08/07/2018	Hardus	Remove Utilisation Section, Update for 46fps demo