

Tiny Yolo v2.0 Polarfire Demo User Guide



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 <u>Pascal Visual Object Classes (VOC)^[1]</u> 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)
 <u>Note:</u> 'device 0' is the default video source which is the built-in camera on a laptop.
 - o Ethernet port
 - o 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
 - o <u>MPF300-EVAL-KIT-ES PolarFire FPGA Evaluation Kit</u>
 - o 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.

	grammers Configuration Customize Help				
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		New Project	Configure Device		
		Open Project 🔄	View Programmers		
		Programmer Name		Programmer Port Type Port	Programmer Programme Status Enabled
E2001UD2RQ		- College		RashPro5 usbE2001UD2RQ (
			Refresh/Rescan for Programmers		

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.

File Edit View Tools Prog	rammers Configuration Customize Help		12 m l m				
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		New Project	Configure Device 💽				
×				 			
1 E2001UD2RQ		Programmer Name		Programmer Type RashPro5	Port usbE2001UD2RQ (Programmer Status	Programmer Enabled
			Refeat/Plescen10 Programmers	17881703	undezwi i Guzina (

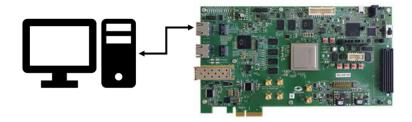
4. Open the 'program_flash.tcl' file and change the 'spi_flash_image' path to match the path where the 'yolo768_t1.bin' file resides.

run_selected_actions \
-disable_prog_design {TRUE} \
-prog_spi_flash {TRUE}
-spi_flash_image {R:/yolo768_tl.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.

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		New Project	Configure Device					
		Open Project	View Programmers	ROGRAM				
		Programmer			Programme	Port	Programmer	Programm
E2001UD2RQ		Programmer Name			Programme Type FlashPro5	Port usbE2001UD2RQ (Programmer Status	Programm Enabled
2001UD2RQ		Execute Script	×	_	Programme Type FlashPro5	Port usbE2001UD2RQ (Programmer Status	Programm Enabled
E2001UD2RQ					Programme Type ReahPro5	Port usbE2001UD2RQ (Programmer Status	Programm Enabled
E2001UD2RQ		Execute Script Script File:	K Brown		Programme Type RathPro5	7 Port UIIDE2001UD2RQ (Programmer Status	Programm Enabled
E2001UD2#Q		Execute Script			Programme Type RashProS	7 Port usbE2001UD2RQ (Programmer Status	Programm Enabled
		Execute Script Scipl File	Browse		Programme Type FashPro5	Port unbE2001UD2RQ (Programmer Status	Programm Enabled
22001U02PG		Execute Script Script File:			Programme Type Facehood	7 Port usbE2001UD2RQ (Programmer Status	Programm Enabler

6. Connect the board directly to the Ethernet port on the PC using a <u>cross-over cable</u>. 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 \rightarrow Network and Internet'. Click on 'Change adapter settings' to view the 'Network Connections'.

	ter htrol Panel > Netwo	rk and Internet > Network and Sharing	Center	
Control Panel Home	· · · · · ·	ur basic network information a	and set up co	nnections
Change adapter settings Change advanced sharing settings	micros	semi.net in network	Access t Connect	ype: Internet tions: 🔊 Wi-Fi 4 (msc-employee)
$ \underbrace{\textcircled{\baselineskip}{2.5 \text{ Network Connections}} }_{\leftarrow} \rightarrow \checkmark \uparrow \underbrace{\textcircled{\baselineskip}{2.5 \text{ Network Connections}} }_{\bullet} \circ \circ$	ntrol Panel > Netwo	rk and Internet > Network Connection	ns	
Organize	rk Connection 4	Ethernet 5		Ethernet 6
Not connected	(Personal Area	Unidentified network Intel(R) Ethernet Connection (4	4) I	Network cable unplugged Fortinet Virtual Ethernet Adapter (
VirtualBox Host- Enabled VirtualBox Host-	Only Network	Wi-Fi 4 microsemi.net Intel(R) Dual Band Wireless-AC	82	

b. Select the appropriate Ethernet connection that will be used to connect to the Polarfire Kit. Right click and open its 'Properties' window.

Petwork Cor → ✓ ↑		vork and Internet → Network Co	Connections
Organize 🔻	Disable this network device	Diagnose this connection	Rename this connection View status of this connecti
Not o	connected	Ethernet 5 Unidentified network Intel(R) Ethernet Con	
Senab	alBox Host-Only Network led alBox Host-Only Ethernet Ad	Wi-Fi 4 microsemi.net Intel(R) Dual Band W	Virel Diagnose
			Bridge Connections
			Create Shortcut
			😌 Delete
			😌 Rename
			Properties

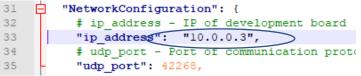
c. Scroll down to find the 'Internet Protocol Version 4 (TCP/IPv4)' property and select it. Click on 'Properties' to assign a Static IP address.

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.

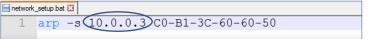
Ethernet 5 Properties	Internet Protocol Version 4 (TCP/IPv4) Properties
Networking Sharing	General
Connect using:	You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Configure This connection uses the following items:	Obtain an IP address automatically Output Use the following IP address:
FortiClient NDIS 5.3 Packet Elter Driver Internet Protocol Version 4 (TCP/IPv4)	IP address: 10 . 0 . 2
Microsoft Network Adapter Multiplexor Protocol	Subnet mask: 255 . 0 . 0 . 0
Microsoft LLDP Protocol Driver Internet Protocol Version 6 (TCP/IPv6)	Default gateway:
Link-Layer Topology Discovery Responder Link-Layer Topology Discovery Mapper I/O Driver	Obtain DNS server address automatically
< >	Use the following DNS server addresses:
Install Uninstall Properties	Preferred DNS server:
Description	Alternate DNS server:
Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.	Validate settings upon exit Advanced
	OK Cancel

Click 'OK' to close the 'Internet Protocol Version 4 (TCP/IPv4)' window.

 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 will 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.

libudp_lib.so libwinpthread-1.dll network_config network_setup opency_ffmpeg300_64.dll	Open Edit	12/5/2017 4:11 PM 3/9/2015 7:50 AM 12/15/2017 3:35 PM	Application extens	
ibudp_lib.so		12/5/2017 4:11 PM 3/9/2015 7:50 AM	SO File Application extens	
Name Name Notate 6.dll Notate 6.dll		Date modified 3/9/2015 8:35 AM 12/11/2017 7:04 PM 12/11/2017 7:04 PM	Type Application extens Application extens A File	See

5. Run '/bin/yolo_demo_threaded.exe' to start the demo.

🔤 moopener_ingrigaio ritaii	2010/01/10 00071111	Approvident excerta	
libopencv_imgcodecs341.dll	2018/07/19 6:39 AM	Application extens	5 558
libopencv_imgproc341.dll	2018/07/19 6:39 AM	Application extens	7 057
libopencv_videoio341.dll	2018/07/19 6:39 AM	Application extens	1 383
libstdc++-6.dll	2017/05/15 11:01	Application extens	1 390
libwinpthread-1.dll	2017/05/11 11:35	Application extens	56
volo demo_threaded.exe	2018/07/25 12:29	Application	1 385

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.

C:\Users\vishakh.rayapeta≻ipconfig
Windows IP Configuration
Ethernet adapter Ethernet 5:
Connection-specific DNS Suffix . :
Link-local IPv6 Address
IPv4 Address
Subnet Mask
Default Gateway :

Physical Address

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

C:\Users\vishakh.rayapeta>arp -a			
Interface: 10.0.0.2	0x14		
Internet Address	Physical Address	Type	
10.0.0.3	c0-b1-3c-60-60-50	static	
10.255.255.255		static	
224.0.0.22			
224.0.0.251			
224.0.0.252			
239.255.255.250			

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.

	Time	C	Destination	Protocol	Length		Info
	Time	Source			Length		
	1 0.000000	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6 5 50636 → 42268 Len=14
	3 0,000179	10.0.0.3	10.0.0.2	UDP			3 42268 → 59636 Len=6
	4 0,000218	10.0.0.2	10.0.0.3	UDP			5 50636 → 42268 Len=14
	5 0.000356	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6
	6 0.000397	10.0.0.2	10.0.0.3	UDP			5 50636 → 50050 Len=0
	7 0.000535	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6
	8 0.000575	10.0.0.2	10.0.0.3	UDP			5 50636 -> 42268 Len=14
	9 0.000715	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6
	10 0.000755	10.0.0.2	10.0.0.3	UDP			5 50636 → 42268 Len=14
	11 0.000886	10.0.0.3	10.0.0.2	UDP			3 42268 → 50636 Len=6
	12 0.000926	10.0.0.2	10.0.0.3	UDP			5 50636 → 42268 Len=14
	13 0.001057	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6
	14 0.001088	10.0.0.2	10.0.0.3	UDP			5 50636 → 42268 Len=14
	15 0.001223	10.0.0.3	10.0.0.2	UDP			3 42268 → 50636 Len=6
	16 0.001251	10.0.0.2	10.0.0.3	UDP			5 50636 → 42268 Len=14
	17 0.001385	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6
	18 0.001416	10.0.0.2	10.0.0.3	UDP			5 52636 → 42268 Len=14
	19 0.001552	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6
	20 0.001583	10.0.0.2	10.0.0.3	UDP			5 50636 → 42268 Len=14
	21 0.001720	10.0.0.3	10.0.0.2	UDP			0 42268 → 50636 Len=6
Ethe Inte	e 1: 60 bytes on w	wire (480 bits) 01:3c:60:60:50 sion 4, Src: 10), 60 bytes ca (c0:b1:3c:60:).0.0.3, Dst:	ptured (480 60:50), Dst: 10.0.0.2		rface	

Miscellaneous

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

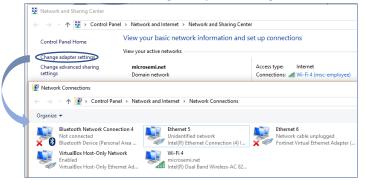
- Cable is securely attached to both the PC and the demo kit.
- LEDs (100MBPS, 1GMBPS LINK) between the Marvell PHY and the FPGA are lit and blinking.
- When reconnecting the cable:
 - \circ Power cycle the board
 - Rerun '/exec/network_setup.bat' as an Administrator.

Advanced Configuration and Usage

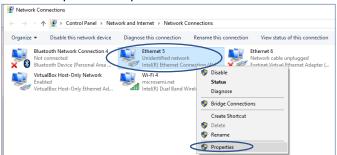
Jumbo Frames

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 \rightarrow 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.

Ethernet 5 Properties	Intel(R) Ethernet Connection (4) I219-V Properties
Networking Sharing	General Advanced Driver Details Events Power Management
Connect using: Thetel(R) Ethemet Connection (4) 1219-V Configure This connection uses the following items: This connection uses the following items: This connection uses the following items: This connection USE 5.3 Packet Fitter Driver This connection USE 5.3 Packet Driver This connection USE 5.3 Packet Driver This connectio	The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right. Property: Adaptive Inter-Frame Spacing Energy Efficient Ethernet Row Control Grapht Master Stave Mode Interrupt Moderation Rate IPv4 Checksum Offload Units Pecket Large Send Offload V2 (IPv4) Large Send Offload V2 (IPv4) Large Send Offload V2 (IPv6) Legacy Switch Compatibility Mode Link Speed Etatery Save Locally Administered Address
	OK Cancel

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 limi€": 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

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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 "data_source" IMAGE" 23
 - "path video": "" 24
- 2. Specify the path the image folder in the `path_image_glob` field. Note that folders must be separated using either "\\" or "/".
 - "path_image_folder": "", "path_image_glob"<"D:/TEMP_DATA/JPEGImages/", "image_extension": "jpg", "capture_source": 0,
- 3. Specify the extension of the image under the `image extension` field.
 - "path_image_folder": "", 28
 - "path image glob": "D:/TEMP DATA/JPEGImages/", "image_extension": "jpg",
 - 30 "capture source":
- 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		1.1.1 and a set of
	Revision	HISTORY
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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