

# 2023년 Deep Learning Hardware 설계 경진대회

2023.1.9 (Mon)



# Road map

About AIX

Environment  
Setting

Code Structure

# Organizing committee

- Representative organizing committee



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- Advisors: 이혁재교수, 이태호교수, 류현석교수, 선우경교수, 이종원교수, 김남준교수, 이재학교수  
서울대학교

# 저작권

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## 저작권 공지

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# Road map

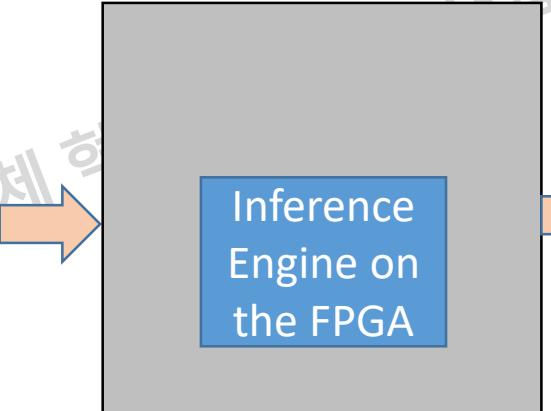
About AIX

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# 설계의 목표

무인판매대에서 상품 인식을 위한 딥러닝 추론  
하드웨어를 설계한다.

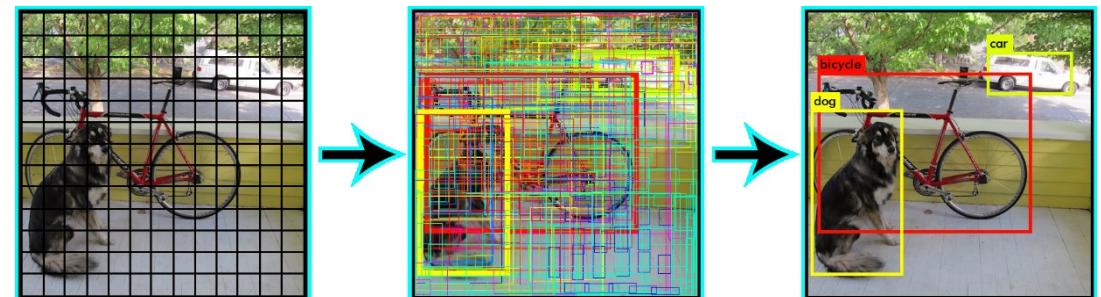


# Object detection (Application-based)

- Training dataset
  - Collected ~100,000 images of items
  - Labeled the data
- We trained a deep neural network (DNN) for object detection based on Tiny-YOLOv4
  - Input: an RGB image
  - The network includes many layer types:
    - Convolutional layers w/ filters 3x3, 1x1
    - Max pooling
    - Concatenation

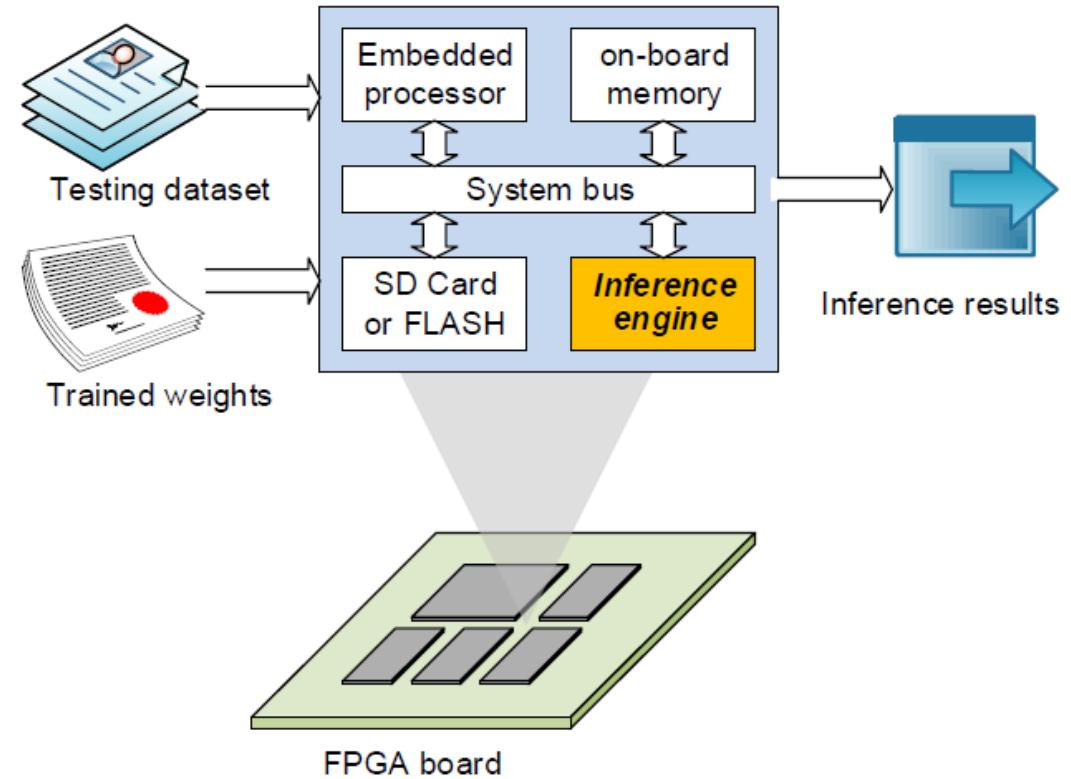


datasets



# 제공되는 것과 준비할 것 (system-based)

- 추론엔진용 딥러닝 파라미터
  - Pretrained model
- 시험 데이터셋 (상품 이미지)
- 추론엔진(Inference Engine)의 reference code
  - S/W: Evaluation and Host PC (C++)
  - H/W: Components (Verilog HDL)
- Nexys A7 FPGA Board (Xilinx Artix-7 FPGA  
XC7A100T-1CSG324C)



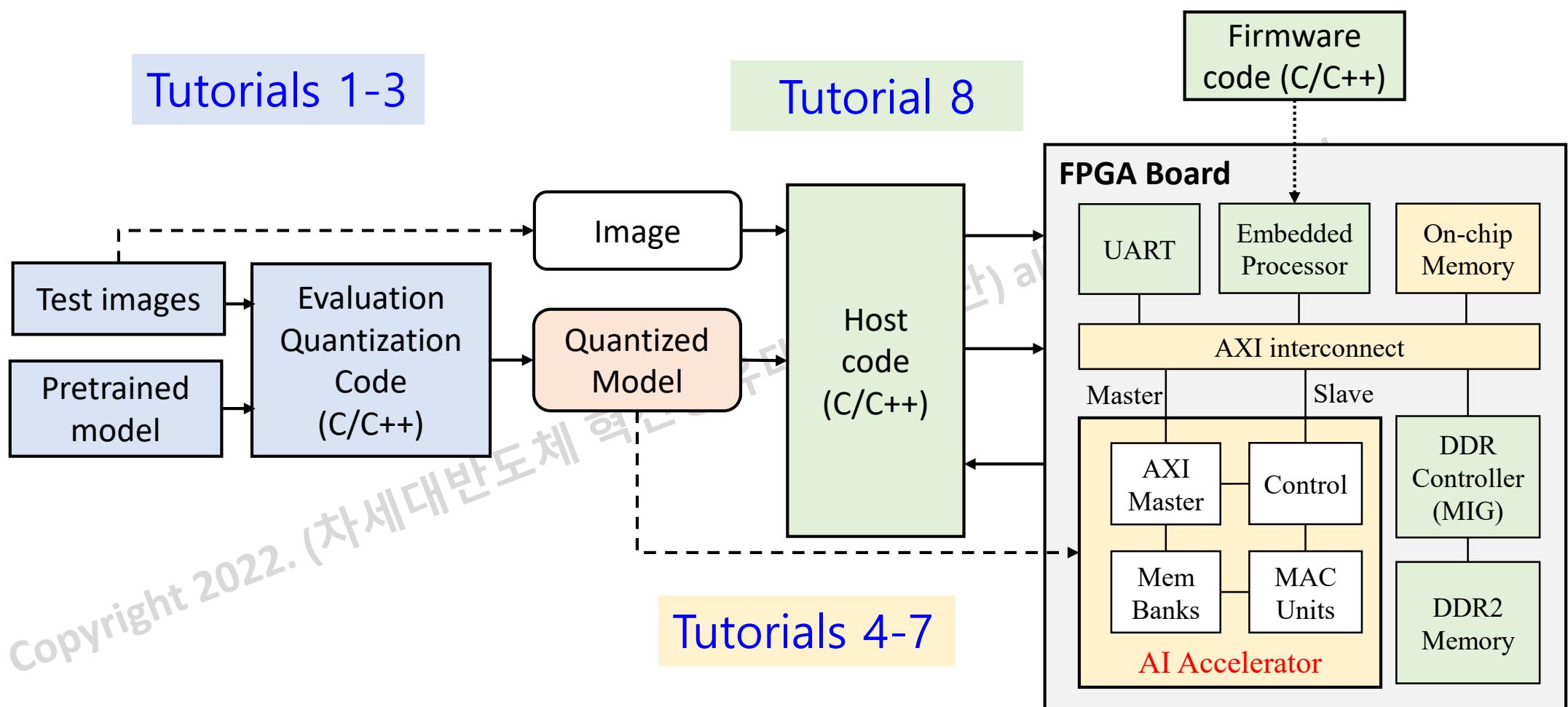
# Tutorials<sup>(1)</sup>

- Four-week tutorials are given to cover several fundamental issues in the AIX Design
  - Introduce fundamental components and their usages

#	Title	Content	Date
1	Orientation	Introduction to AIX, code structure	2/9 (Mon)
2	Network	Reference S/W, network architecture, evaluation metrics	Youtube
3	Quantization	Model quantization, data preparation	Youtube
4	MAC	Hardware description language, computing units	Youtube
5	Memory	On-chip buffer, block RAM, IP generator, MIG	Youtube
6	Bus	AXI interconnect, DMA	Youtube
7	Integration	System integration and verification (one layer)	Youtube
8	CPU-FPGA	PC-FPGA communication	Youtube

<sup>(1)</sup> Tutorials do NOT aim to replace courses at school. Students are highly recommended to take relevant courses.

# Top structure and tutorials



# 경진대회 개최 일정

- 공지 및 접수 : 22.12.12 (월)~23.1.6 (금)
  - 사전 온라인 설명회 : 22.12.21(수) 오후 3시 온라인(Zoom)으로 진행
- 오리엔테이션 : 1.9 (월) 5시 온라인(Zoom)으로 진행
- 본선 : 1.9 (월) ~ 5.19 (금, 최종 설계 제출 마감)
  - 중간 평가 : 2.24 (금) → Progress checking
  - Submit both the code and presentation. A template will be given.
- 최우수팀 선정 및 시상식 : 5.26 (금) 온라인(Zoom)으로 진행

# Registration

## ■ 대상 및 자격

- 차세대 반도체 혁신공유대학 (강원대, 대구대, 서울대, 숭실대, 조선이공대, 중앙대, 포항공 대) 학부생 2~3인 구성의 팀으로 딥러닝과 하드웨어에 관심있는 누구나 참여 가능 (단, 2023년 1학기를 기준으로 재학 상태여야 함)

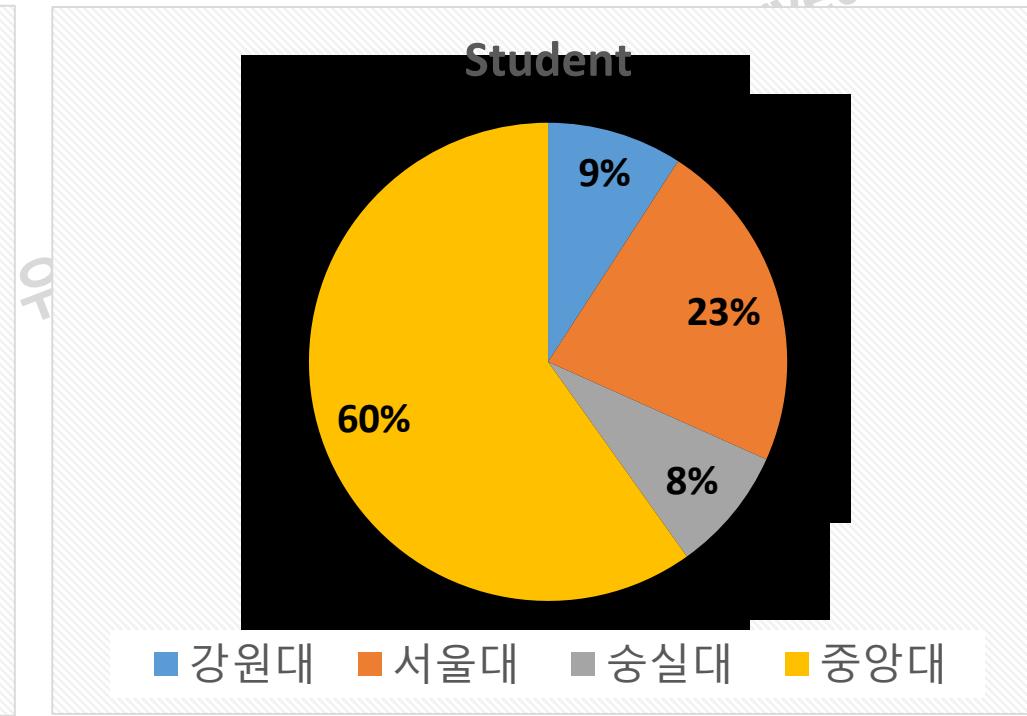
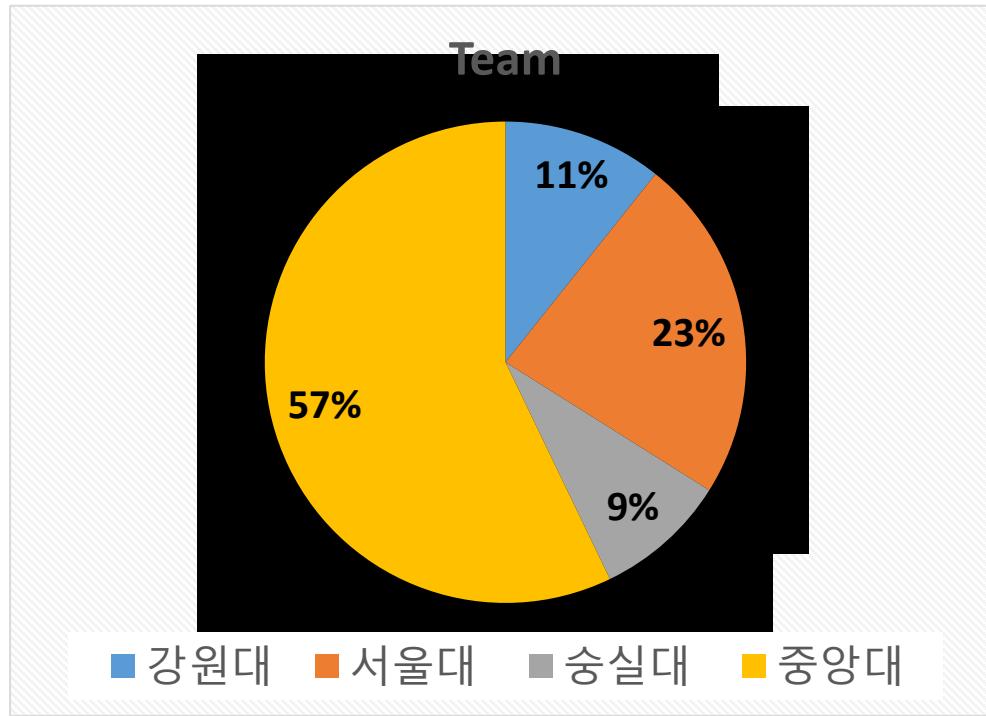
- 자격 제한 : 2022년도 AI Hardware 설계 경진대회(주관처 동일의) 수상팀접수

## ■ 접수 방법(지원서는 개인별로 작성하여 제출)

- <https://forms.gle/86TbEfBuW3k6Tu9y7>

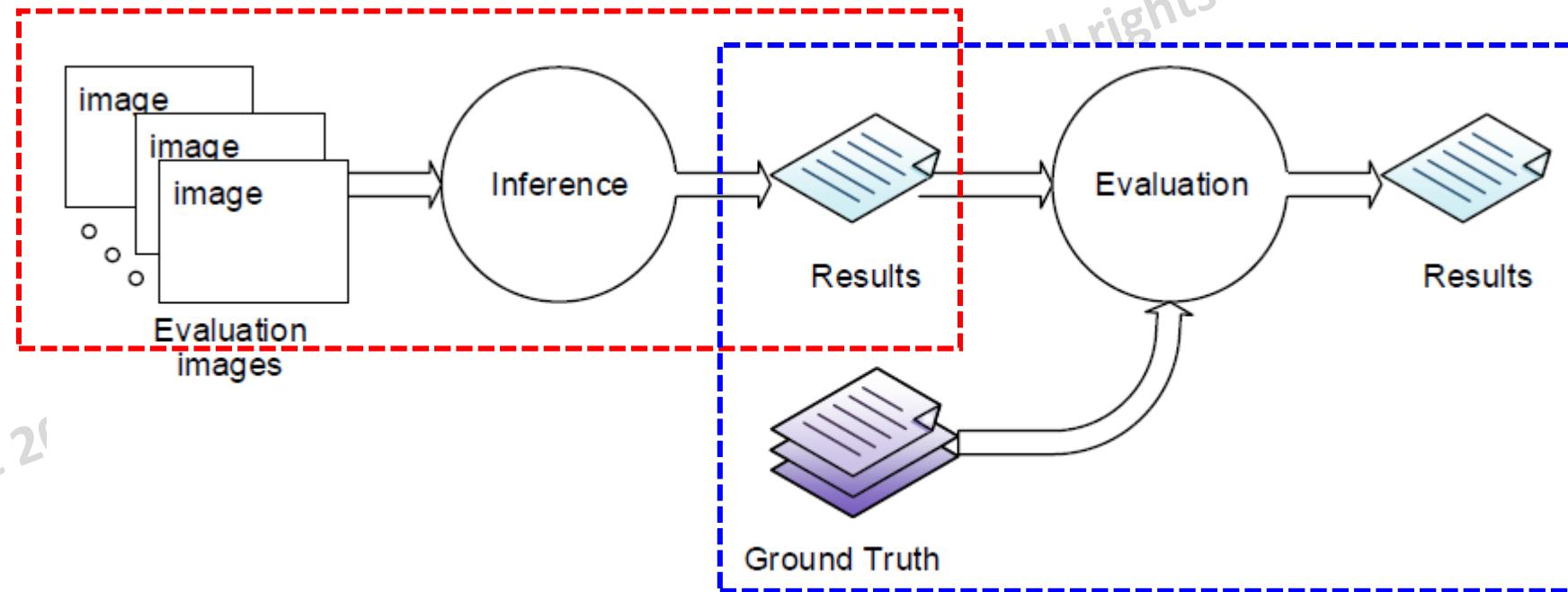
# Registration

- 142 students in 58 teams from four schools (강원대, 서울대, 숭실대, 중앙대)



# 결과평가: Accuracy

- 평가 데이터셋 (참가자에게 공개하지 않음)
  - ▶ Images of product items
  - ▶ Mean-average precision (mAP): Quantized model



# 결과평가: Accuracy

- The intersection of Union (IoU)
  - Intersection: The overlapped area between two bounding boxes
  - Union: Combined area of two bounding boxes
- Mean average precision (mAP)
  - Calculate the AP at IoU threshold 0.5.
  - INT8 quantized accuracy.
- The code for evaluation is given



```
class_id = 9, name = listerine_green, ap = 100.00 %
class_id = 10, name = mahatma_rice, ap = 100.00 %
class_id = 11, name = white_rain_body_wash, ap = 100.00 %
class_id = 12, name = pringles_bbq, ap = 80.34 %
class_id = 13, name = cheeze_it, ap = 100.00 %
class_id = 14, name = hersheys_bar, ap = 64.78 %
class_id = 15, name = redbull, ap = 83.35 %
class_id = 16, name = mom_to_mom_sweet_potato_corn_apple, ap = 97.14 %
class_id = 17, name = a1_steak_sauce, ap = 50.80 %
class_id = 18, name = jif_creamy_peanut_butter, ap = 90.71 %
class_id = 19, name = cinnamon_toast_crunch, ap = 95.97 %
class_id = 20, name = arm_hammer_baking_soda, ap = 96.51 %
class_id = 21, name = dr_pepper, ap = 100.00 %
class_id = 22, name = haribo_gold_bears_gummi_candy, ap = 97.56 %
class_id = 23, name = bulls_eye_bbq_sauce_original, ap = 100.00 %
class_id = 24, name = reeses_pieces, ap = 100.00 %
class_id = 25, name = clif_crunch_peanut_butter, ap = 83.60 %
class_id = 26, name = mom_to_mom_butternut_squash_pear, ap = 95.71 %
class_id = 27, name = pop_tararts_strawberry, ap = 95.70 %
class_id = 28, name = quaker_big_chewy_chocolate_chip, ap = 74.60 %
class_id = 29, name = spam, ap = 56.44 %
class_id = 30, name = coffee_mate_french_vanilla, ap = 96.32 %
class_id = 31, name = pepperidge_farm_milk_chocolate_macadamia_cookies, ap = 87.99 %
class_id = 32, name = kitkat_king_size, ap = 75.14 %
class_id = 33, name = snickers, ap = 1.02 %
class_id = 34, name = toblerone_milk_chocolate, ap = 82.28 %
class_id = 35, name = clif_z_bar_chocolate_chip, ap = 97.37 %
class_id = 36, name = nature_valley_crunchy_oats_n_honey, ap = 100.00 %
class_id = 37, name = ritz_crackers, ap = 98.36 %
class_id = 38, name = palmlive_orange, ap = 86.36 %
class_id = 39, name = crystal_hot_sauce, ap = 87.92 %
class_id = 40, name = tapatio_hot_sauce, ap = 78.41 %
class_id = 41, name = nabisco_nilla_wafers, ap = 97.69 %
class_id = 42, name = pepperidge_farm_milano_cookies_double_chocolate, ap = 90.33 %
class_id = 43, name = campbells_chicken_noodle_soup, ap = 100.00 %
class_id = 44, name = frappuccino_coffee, ap = 100.00 %
class_id = 45, name = chewy_dins_chocolate_chips, ap = 77.22 %
```

```
for thresh = 0.24, precision = 0.84, recall = 0.81, F1-score = 0.83
for thresh = 0.24, TP = 2411, FP = 450, FN = 548, average IoU = 66.30 %
```

```
mean average precision (mAP) = 0.878705, or 87.87 %
```

```
class_id = 46, name = dove_dark_chocolate, ap = 99.64 %
class_id = 47, name = dove_white, ap = 99.64 %
class_id = 48, name = david_sunflower_seeds, ap = 100.00 %
class_id = 49, name = monster_energy, ap = 63.64 %
class_id = 50, name = nestle_tollhouse_chocolate_chips_cookie, ap = 99.64 %
class_id = 51, name = nestle_tollhouse_chocolate_chips_cookie, ap = 99.64 %
class_id = 52, name = nestle_tollhouse_chocolate_chips_cookie, ap = 99.64 %
class_id = 53, name = nestle_tollhouse_chocolate_chips_cookie, ap = 99.64 %
class_id = 54, name = dove_white, ap = 99.64 %
class_id = 55, name = david_sunflower_seeds, ap = 100.00 %
class_id = 56, name = monster_energy, ap = 63.64 %
class_id = 57, name = act_iit_butter_lovers_popcorn, ap = 91.62 %
class_id = 58, name = coca_cola_glass_bottle, ap = 87.92 %
class_id = 59, name = twix, ap = 81.82 %
for thresh = 0.24, precision = 0.84, recall = 0.81, F1-score = 0.83
for thresh = 0.24, TP = 2411, FP = 450, FN = 548, average IoU = 66.30 %
```

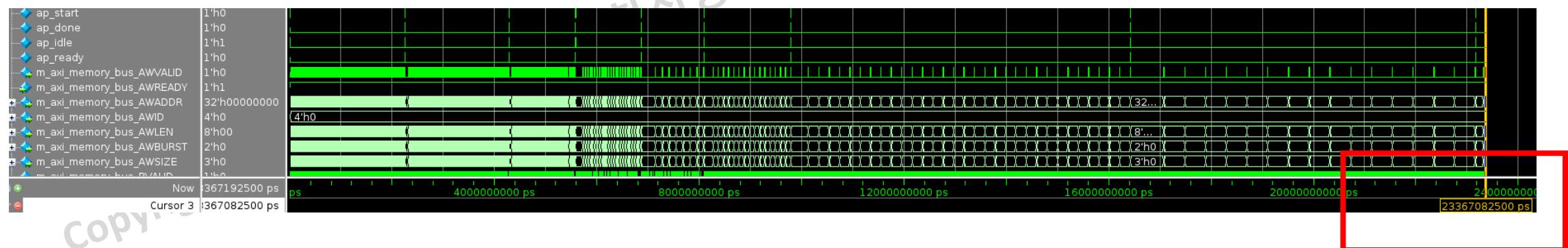
```
mean average precision (mAP) = 0.878705, or 87.87 %
```

```
Total Detection time: 27.000000 Seconds
```

```
(base) truongnx@marlin:~/atx2023/skeleton$ █
```

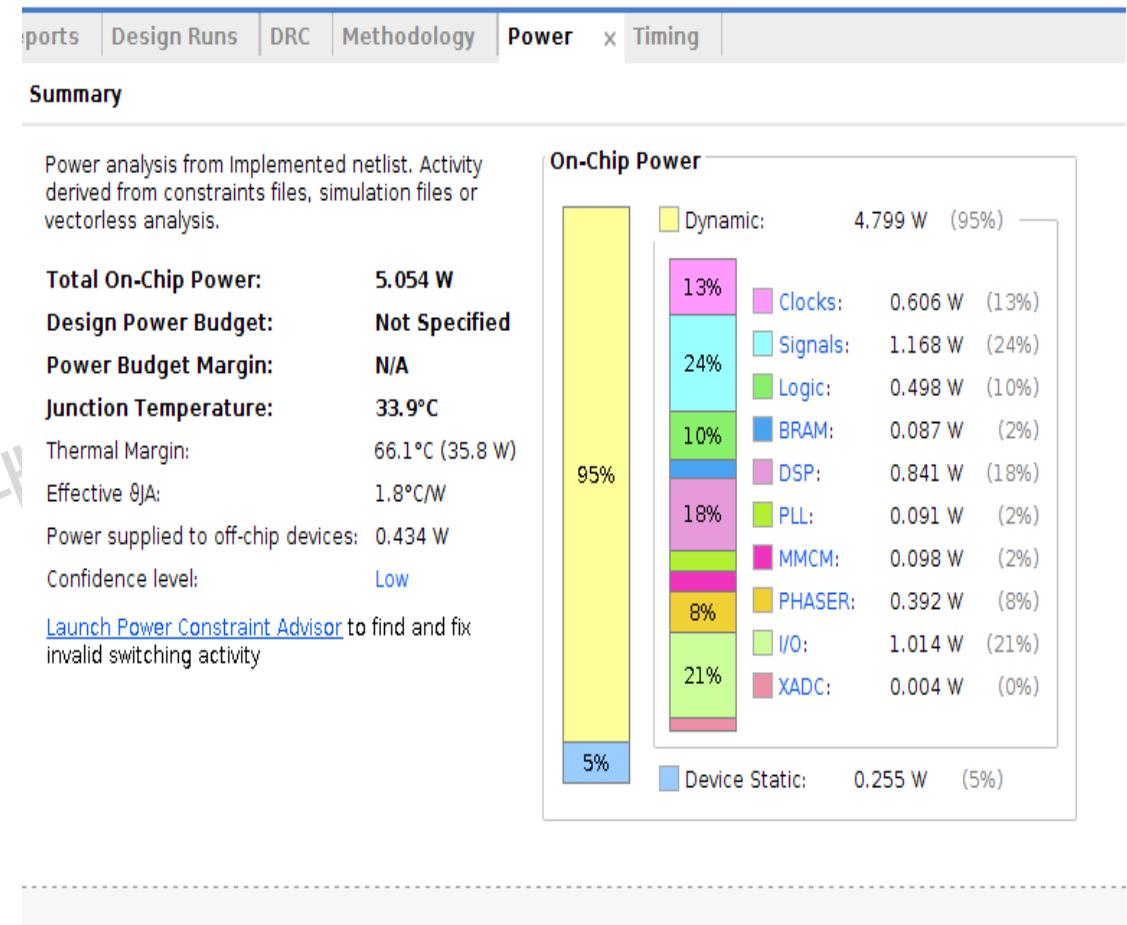
# 결과평가: Inference speed

- Inference speed measures the number of frames your CNN accelerator IP processes in a second
- RTL simulation result
  - Example:
    - 200MHz, 2 cycle for DRAM latency
    - 23.3ms



# 결과평가: Energy

- Implement your design on an FPGA board
- Measure the on-chip power of the design after FPGA implementation
  - Logic
  - Memory
  - DSP
  - IO



# Evaluation

- 중간 평가: 2.24 (금): Only for progress checking, No elimination
  - Quantized model
  - RTL simulation for the **three-first** CONV layers.  
⇒ Submit your code and report<sup>(1)</sup>.
- 최종 평가: 5.19 (금)
  - Accuracy
  - Speed
  - Power
  - Presentation
  - ⇒ Submit your code, design, and report<sup>(2)</sup>.

<sup>(1)-(2)</sup> The template and the submission guidelines will be provided later.

# Evaluation: Midterm (Progress checking)

- Software (25p)
  - Check how to understand a Deep network operation, and prepare the data for H/W implementation.
  - **Mean Average Precision** (mAP(%)): Evaluate the accuracy of the model and activation quantization.
  - **Test vector: Generate input data** (e.g., an input image, filters) and the **output data** (e.g., feature maps for Layers 1-3)
- Hardware Design (50p)
  - Design DSP/MAC, buffers, and a controller (e.g., FSM) for multi-layer operations
  - Implement normalization (e.g., scaling/descaling, adding a bias), activation, quantization, and max-pooling.
  - Verify the outputs of RTL simulation for three CONV layers.
- Presentation (25p)
  - Explain the results.
  - Explain your quantization method, dataflow, implementation ideas, and algorithms.
  - Distribute tasks among members, and make a plan

# (Tentative) Evaluation: Final

- Objective evaluation<sup>(1)</sup>

- $10^4 / \text{Energy} * \text{ReLU (mMAP - 0.2)} * \text{ReLU (fps - 5)}$ .
- Where mMAP is the INT8 quantized accuracy

*(1) if the team completes the design until the FPGA verification.*

- Subjective evaluation<sup>(2)</sup>

- Software (25p)
- Hardware Design (50p)
- Presentation (25p)

*(2) When the design is NOT completed.*

# 대회 최우수팀 수상 및 상품

- 평가 점수 기준 최우수팀 및 우수팀 선정 (3등까지)
  - 1등 : 노트북 (one team)
  - 2등 : 갤럭시 탭 (one team)
  - 3등 : 1갤럭시 버즈 (two teams)
- 중간 평가 결과 우수한 팀에게 Starbucks coffee coupons 증정

# Road map

About AIX

Environment  
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Code Structure

# Software Development Kit Environment

- Software for model quantization
  - C/C++: OS: Windows (Visual Studio (2019<sup>(1)</sup>)), Linux (gcc (7.5.0<sup>(2)</sup>) on Ubuntu 18.04)), Mac (gcc)
  - Python (3.7.9<sup>(3)</sup> or 2.7.17<sup>(4)</sup>)
    - Automatically generate the directories for test images.
    - Optional: Analyze data for quantization.
  - *(1),(2),(3),(4) the code is likely to work fine with other versions. We will give additional support if needed.*
- Hardware implementation
  - Xilinx Vivado 2021.1:
    - RTL simulation and verification, IP Packaging, Synthesis, and FPGA implementation.
    - Only support Windows and Linux versions. *For a Mac OS, need to install a virtual machine*  
⇒ *You should utilize a desktop PC in the laboratories at your school*
- System Integration
  - Host code: (1) C/C++, or (2) Python
  - Xilinx Vitis 2021.1 (C/C++)
    - Make the firmware code

# Q1: How to compile the code with VS

- Step 1: I assume that skeleton-v1.2 is downloaded and extracted at C:\skeleton-v1.2\skeleton-v1.2
- Step 2: Install Python on Windows.
  - You can go to <https://www.python.org/downloads/release/python-2718/> to download Python2.7.
  - The version is [Windows x86-64 MSI installer](#)

## Files

Version	Operating System	Description	MD5 Sum	File Size	GPG
<a href="#">Gzipped source tarball</a>	Source release		38c84292658ed4456157195f1c9bcbe1	17539408	<a href="#">SIG</a>
<a href="#">XZ compressed source tarball</a>	Source release		fd6cc8ec0a78c44036f825e739f36e5a	12854736	<a href="#">SIG</a>
<a href="#">macOS 64-bit installer</a>	macOS	for OS X 10.9 and later	ce98eeb7bdf806685adc265ec1444463	24889285	<a href="#">SIG</a>
<a href="#">Windows debug information files</a>	Windows		20b111ccfe8d06d2fe8c77679a86113d	25178278	<a href="#">SIG</a>
<a href="#">Windows debug information files for 64-bit binaries</a>	Windows		bb0897ea20fda343e5179d413d4a4a7c	26005670	<a href="#">SIG</a>
<a href="#">Windows help file</a>	Windows		b3b753dff1c7930243c1c40ec3a72b1	6322188	<a href="#">SIG</a>
<a href="#">Windows x86-64 MSI installer</a>	Windows	for AMD64/EM64T/x64	a425c758d38f8e28b56f4724b499239a	20598784	<a href="#">SIG</a>
<a href="#">Windows x86 MSI installer</a>	Windows		db6ad9195b3086c6b4cef9493d738d2	19632128	<a href="#">SIG</a>

# Q1: How to compile the code with VS

- Step 3: Install Python27. After installing Python, it exists at C:\Python27

Name	Date modified	Type	Size
Doc	3/7/2022 8:55 PM	File folder	
include	3/7/2022 8:55 PM	File folder	
Lib	3/7/2022 8:55 PM	File folder	
libs	3/7/2022 8:55 PM	File folder	
Scripts	3/7/2022 8:55 PM	File folder	
tcl	3/7/2022 8:55 PM	File folder	
Tools	3/7/2022 8:55 PM	File folder	
LICENSE.txt	4/20/2020 1:34 PM	Text Document	38 KB
NEWS.txt	4/20/2020 1:30 PM	Text Document	509 KB
python.exe	4/20/2020 1:26 PM	Application	28 KB
pythonw.exe	4/20/2020 1:26 PM	Application	28 KB

# Q1: How to compile the code with VS

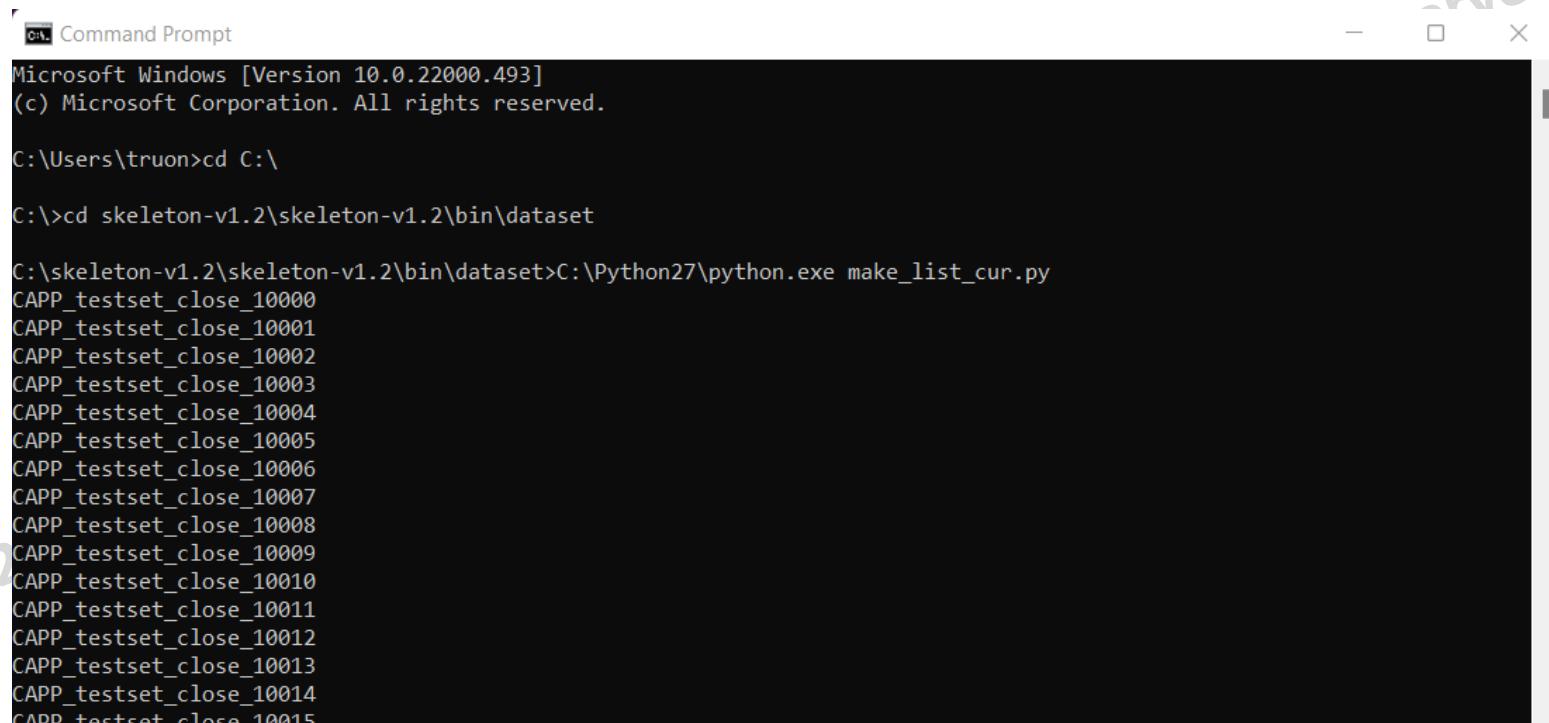
- Step 4: Make the list of files at bin/dataset/.

Open Command Prompt

cd C:\

cd skeleton-v1.2\skeleton-v1.2\bin\dataset

C:\Python27\python.exe make\_list\_cur.py



The screenshot shows a Windows Command Prompt window with the title 'Command Prompt'. The window displays the following text:

```
Microsoft Windows [Version 10.0.22000.493]
(c) Microsoft Corporation. All rights reserved.

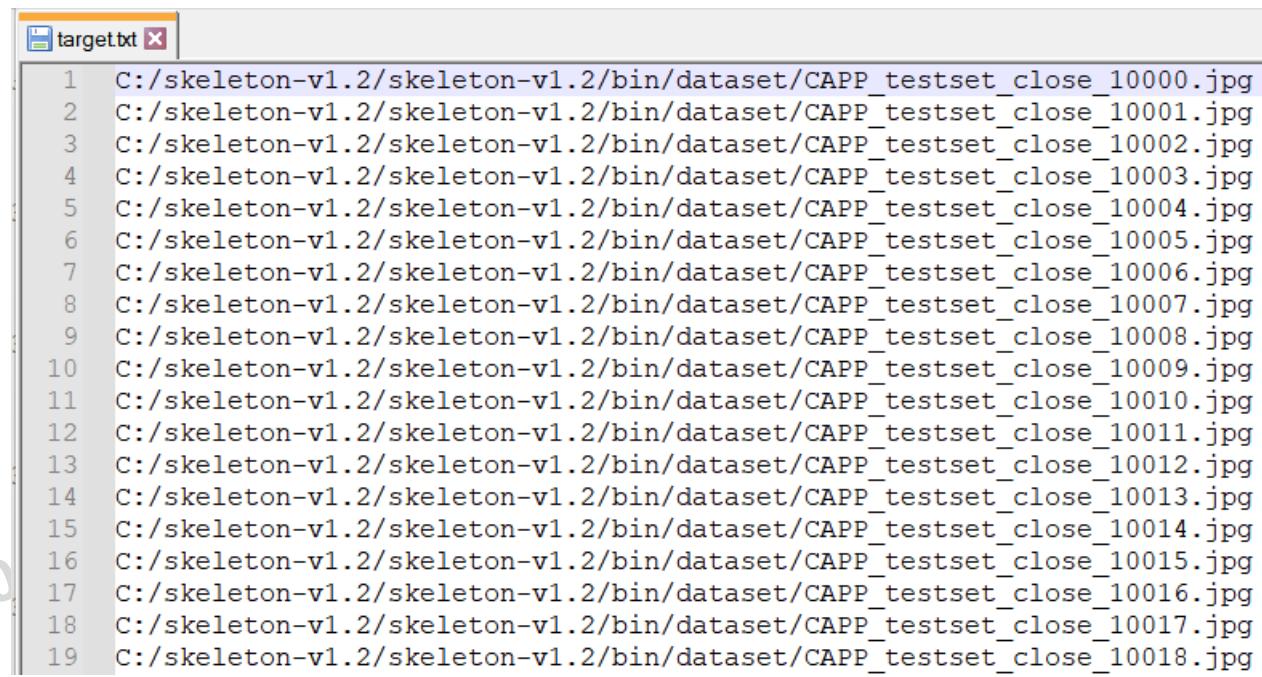
C:\Users\truong>cd C:\

C:\>cd skeleton-v1.2\skeleton-v1.2\bin\dataset

C:\skeleton-v1.2\skeleton-v1.2\bin\dataset>C:\Python27\python.exe make_list_cur.py
CAPP_testset_close_10000
CAPP_testset_close_10001
CAPP_testset_close_10002
CAPP_testset_close_10003
CAPP_testset_close_10004
CAPP_testset_close_10005
CAPP_testset_close_10006
CAPP_testset_close_10007
CAPP_testset_close_10008
CAPP_testset_close_10009
CAPP_testset_close_10010
CAPP_testset_close_10011
CAPP_testset_close_10012
CAPP_testset_close_10013
CAPP_testset_close_10014
CAPP_testset_close_10015
```

# Q1: How to compile the code with VS

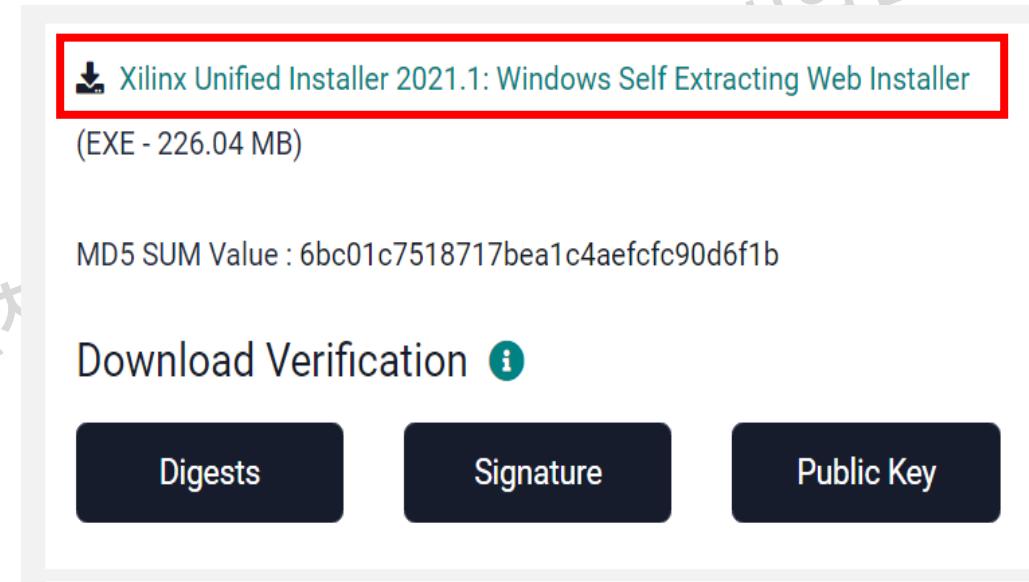
- Now you can check the file target.txt at C:\skeleton-v1.2\skeleton-v1.2\bin\dataset.
- As shown in the following figure, all directories of images are updated with "C:\skeleton-v1.2\skeleton-v1.2\bin\dataset"



```
target.txt
1 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10000.jpg
2 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10001.jpg
3 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10002.jpg
4 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10003.jpg
5 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10004.jpg
6 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10005.jpg
7 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10006.jpg
8 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10007.jpg
9 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10008.jpg
10 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10009.jpg
11 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10010.jpg
12 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10011.jpg
13 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10012.jpg
14 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10013.jpg
15 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10014.jpg
16 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10015.jpg
17 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10016.jpg
18 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10017.jpg
19 C:/skeleton-v1.2/skeleton-v1.2/bin/dataset/CAPP_testset_close_10018.jpg
```

# Download Vivado

- Visit Xilinx website to download vivado
    - <https://www.xilinx.com/support/download.html>
  - Here, select a version and download
  - This tutorial will explain using the 2021.1 version
  - You have to create a Xilinx account to install Vivado
- We will provide a separate tutorial for this installation



# Road map

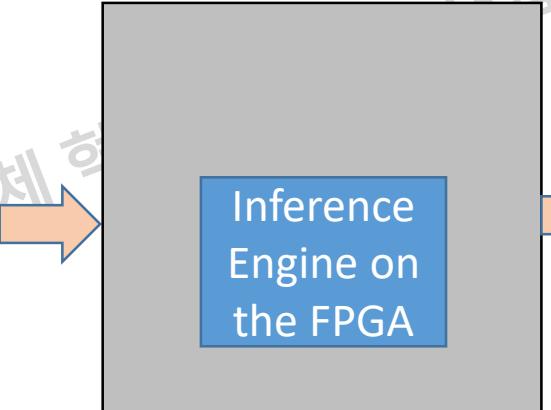
About AIX

Environment  
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Code Structure

# 설계의 목표

무인판매대에서 상품 인식을 위한 딥러닝 추론  
하드웨어를 설계한다.

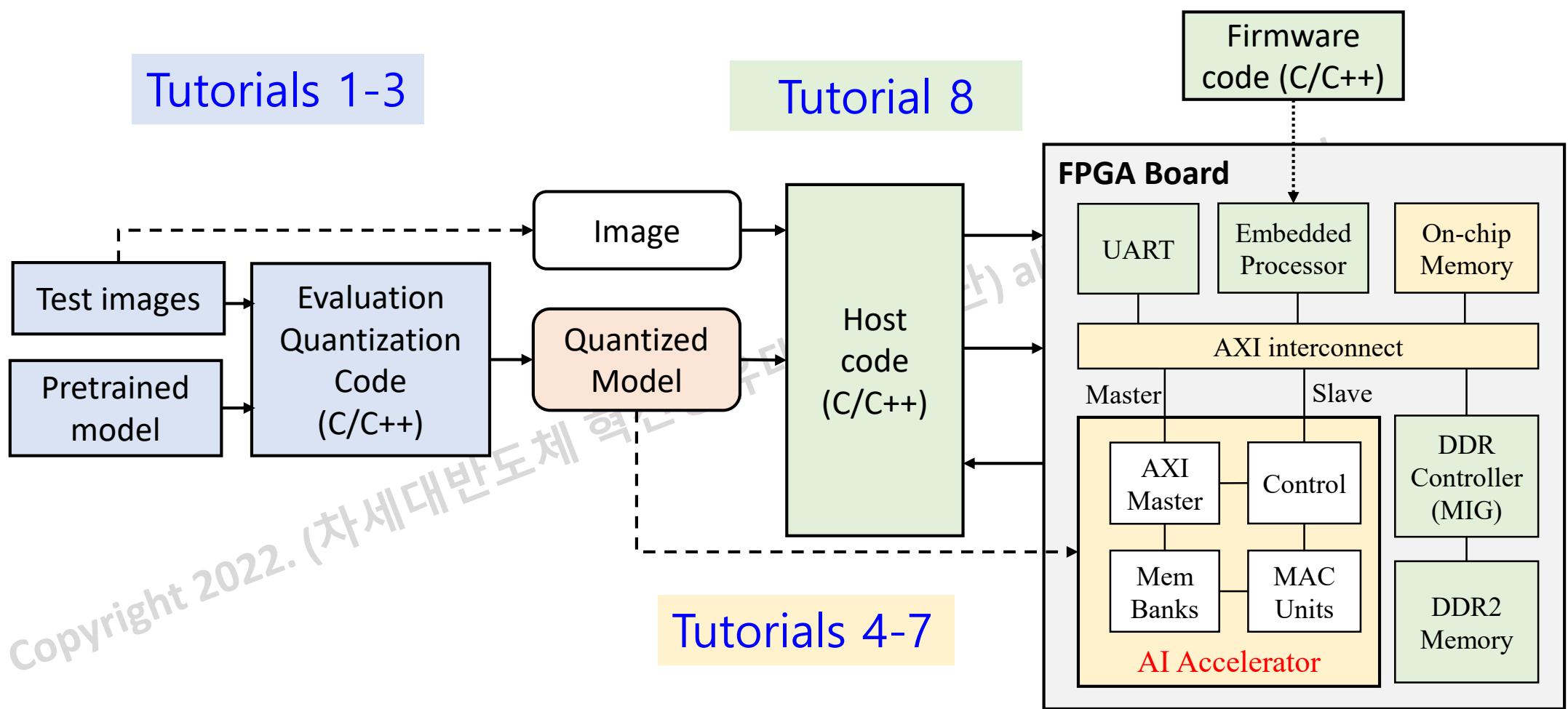


# Object detection

- Object detection = Proposal + Classification
  - Proposal: Location of an object
    - Bounding boxes: a rectangle bounding an object
  - Classification: an object's class
    - Indicate by its box's color and name tag



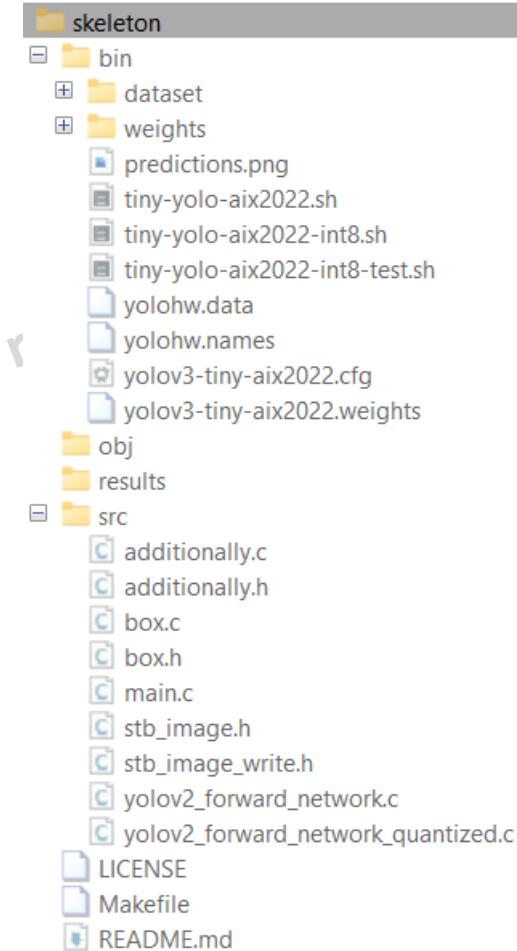
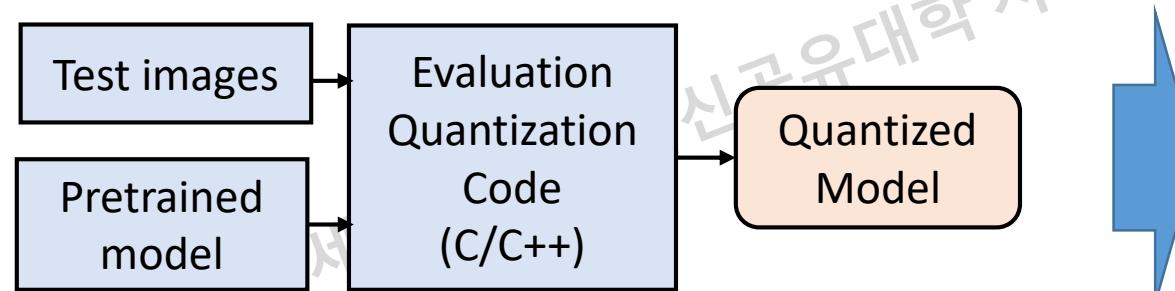
# Top structure and tutorials



# Tutorials 1-3: Reference S/W

- Skeleton

- Test images, object classes, and ground truth
- Pretrained model
- Reference code for evaluation and quantization
- The S/W code is based on the darknet code



# Test images (skeleton/bin/dataset)

- Test images in two categories
  - Long: distances among objects are far
  - Close: items are close
- Execute a UNIX command: *python make\_list\_cur.py*
  - Get directories of all images and store them to target.txt



long



close

# Test images (skeleton/bin/dataset)

- Ground truth: \*.txt files
  - Each line represents a labelled object
    - [class\_index x\_pos y\_pos width height]
- yolohw.names: names of all 60 classes of products

```
1 12 0.1997395833333333 0.3916666666666666 0.0671875 0.2777777777777778
2 13 0.26484375 0.39351851851855 0.1265625 0.2796296296296296
3 11 0.3419270833333333 0.3847222222222224 0.0630208333333333 0.287962962962963
4 6 0.4427083333333333 0.3305555555555555 0.178125 0.4425925925925926
5 0 0.5614583333333333 0.3842592592592593 0.090625 0.3388888888888889
6 9 0.6377604166666666 0.3773148148148148 0.0901041666666667 0.325
7 7 0.7296875 0.3699074074074074 0.1489583333333333 0.34351851851851856
8 1 0.1981770833333334 0.649537037037037 0.0807291666666667 0.1805555555555555
9 2 0.2671875 0.70416666666667 0.0864583333333333 0.1824074074074074
10 3 0.30859375 0.6421296296296296 0.0859375 0.3212962962962963
11 4 0.3890625 0.7495370370370371 0.090625 0.1787037037037037
12 14 0.4559895833333334 0.78472222222222 0.0734375 0.23425925925925928
13 10 0.621875 0.7532407407407408 0.25625 0.23425925925925928
14 5 0.765625 0.6810185185186 0.1104166666666666 0.21574074074074076
15 8 0.825 0.6587962962962963 0.0927083333333334 0.23240740740740742
16
```

CAPP\_testset\_close\_10000.txt

```
1 aunt_jemima_original_syrup
2 band_aid_clear_strips
3 bumblebee_albacore
4 cholula_chipotle_hot_sauce
5 crayola_24_crayons
6 hersheys_cocoa
7 honey_bunches_of_oats_honey_roasted
8 honey_bunches_of_oats_with_almonds
9 hunts_sauce
10 listerine_green
11 mahatma_rice
12 white_rain_body_wash
13 pringles_bbq
14 cheeze_it
15 hersheys_bar
16 redbull
```

yolohw.names

# Pretrained model (skeleton/bin)

- A pretrained model is defined by two files
  - `yolov4-tiny-aix2023.cfg`: Network's configuration
    - Input size
    - Training/testing options
    - Layer's settings
  - `yolov4-tiny-aix2023.weights`
    - 32-bit floating point parameters

```
1 [net]
2 # Testing
3 batch=1
4 subdivisions=1
5 # Training
6 #batch=64
7 #subdivisions=2
8 width=320
9 height=320
10 channels=3
11 momentum=0.9
12 decay=0.0005
13 angle=0
14 saturation = 1.5
15 exposure = 1.5
16 hue=.1
17
18 learning_rate=0.001
19 burn_in=1000
20 max_batches = 50200
21 policy=steps
22 steps=40000,45000
23 scales=.1,.1
24
25 [convolutional]
26 batch_normalize=1
27 filters=16
28 size=3
29 stride=1
30 pad=1
31 activation=leaky
32
33 [maxpool]
```

# Source files

- additionally.c // Definitions of darknet functions used
- additionally.h // Declaration of darknet functions + additional functions for forward pass of yolo model
- box.c      } // For bounding boxes
- box.h      }
- stb\_image\_write.h      } // For loading/writing images
- stb\_image.h      }
- yolov2\_forward\_network.c // Functions for forward pass of yolo network
- **yolov2\_forward\_network\_quantized.c** // Functions for quantization, saving of the quantized model, and the forward pass of quantized yolo model
- main.c // The main functions

 You should mainly edit this file for quantization!

# How to Compile & Run?

- Use the provided **Makefile** to compile
- Run **bin/darknet** with appropriate arguments
  - *Example*
    - *tiny-yolo-aix2023.sh*
    - *tiny-yolo-aix2023-int8.sh*
    - *tiny-yolo-aix2023-int8-test.sh*

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# How to Compile & Run?

e.g.) tiny-yolo-aix2022-int8.sh

```
./darknet detector map yolohw.names yolov3-tiny-aix2022.cfg yolov3-tiny-aix2022.weights -thresh 0.24 -quantized -save_params
```

To calculate mAP using the provided dataset, use 'map'.  
To visualize a detection result for an image, use 'test'.

Different threshold values result in different precision, recall, and F1 score.

To evaluate the quantized model, use '-quantized' option.

To save the quantized model (quantized weights, biases, and input scale factor) to bin/weights, use '-save\_params' option.

# Flow

- Extract the file and type the following commands

- cd skeleton/

- make

→ Compile the code, the executable file is written to bin/

- cd bin/dataset/

- python make\_list\_cur.py

→ Generate the directories for the test images

- cd ..

→ Back to bin/

- ./tiny-yolo-aix2023.sh

→ Test the model with the test images.

# Experimental results: Loading a model

```
(base) truongnx@marlin:~/aix2023/skeleton$ cd bin; ./tiny-yolo-aix2023-int8.sh; cd ..
valid: Using default 'dataset/target.txt'
names: Using default 'yolohw.names'
layer    filters      size           input          output
       0 conv      16 3 x 3 / 2   256 x 256 x 3    -> 128 x 128 x 16 0.014 BF
       1 conv      32 3 x 3 / 2   128 x 128 x 16    -> 64 x 64 x 32 0.038 BF
       2 conv      32 3 x 3 / 1    64 x 64 x 32    -> 64 x 64 x 32 0.075 BF
       3 route     2
       4 conv      16 3 x 3 / 1    64 x 64 x 16    -> 64 x 64 x 16 0.019 BF
       5 conv      16 3 x 3 / 1    64 x 64 x 16    -> 64 x 64 x 16 0.019 BF
       6 route     5 4
       7 conv      32 1 x 1 / 1    64 x 64 x 32    -> 64 x 64 x 32 0.008 BF
       8 route     2 7
       9 max
      10 conv      64 3 x 3 / 1   32 x 32 x 64    -> 32 x 32 x 64
      11 route    10
      12 conv      32 3 x 3 / 1   32 x 32 x 32    -> 32 x 32 x 32 0.019 BF
      13 conv      32 3 x 3 / 1   32 x 32 x 32    -> 32 x 32 x 32 0.019 BF
      14 route    13 12
      15 conv      64 1 x 1 / 1   32 x 32 x 64    -> 32 x 32 x 64 0.008 BF
      16 route    10 15
      17 max
      18 conv      128 3 x 3 / 1  16 x 16 x 128   -> 16 x 16 x 128 0.075 BF
      19 route    18
      20 conv      64 3 x 3 / 1   16 x 16 x 64    -> 16 x 16 x 64 0.019 BF
      21 conv      64 3 x 3 / 1   16 x 16 x 64    -> 16 x 16 x 64 0.019 BF
      22 route    21 20
      23 conv      128 1 x 1 / 1  16 x 16 x 128   -> 16 x 16 x 128 0.008 BF
      24 route    18 23
      25 max
      26 conv      256 3 x 3 / 1  8 x 8 x 256    -> 8 x 8 x 256 0.075 BF
      27 conv      195 1 x 1 / 1  8 x 8 x 256    -> 8 x 8 x 195 0.006 BF
      28 yolo
      29 route    25
      30 conv      64 1 x 1 / 1   8 x 8 x 256    -> 8 x 8 x 64 0.002 BF
      31 upsample
      32 route    31 23
      33 conv      195 1 x 1 / 1  16 x 16 x 192   -> 16 x 16 x 195 0.019 BF
      34 yolo
Total BFLOPS 0.520
Loading weights from yolov4-tiny-aix2023.weights...
```

# Experimental results: Accuracy

- Report the accuracy of all 60 items
- The 32-bit model achieves the mean average precision (mAP) is 87.87%(1).
- (1) If you run the code with a Mac OS, the result might be slightly different
  - MAC OS uses BFLOAT while Windows or Linux OS uses FP

```
class_id = 9, name = listerine_green, ap = 100.00 %
class_id = 10, name = mahatma_rice, ap = 100.00 %
class_id = 11, name = white_rain_body_wash, ap = 100.00 %
class_id = 12, name = pringles_bbq, ap = 80.34 %
class_id = 13, name = cheeze_it, ap = 100.00 %
class_id = 14, name = hersheys_bar, ap = 64.78 %
class_id = 15, name = redbull, ap = 83.35 %
class_id = 16, name = mom_to_mom_sweet_potato_corn_apple, ap = 97.14 %
class_id = 17, name = a1_steak_sauce, ap = 50.80 %
class_id = 18, name = jif_creamy_peanut_butter, ap = 90.71 %
class_id = 19, name = cinnamon_toast_crunch, ap = 95.97 %
class_id = 20, name = arm_hammer_baking_soda, ap = 96.51 %
class_id = 21, name = dr_pepper, ap = 100.00 %
class_id = 22, name = haribo_gold_bears_gummi_candy, ap = 97.56 %
class_id = 23, name = bulls_eye_bbq_sauce_original, ap = 100.00 %
class_id = 24, name = reeses_pieces, ap = 100.00 %
class_id = 25, name = clif_crunch_peanut_butter, ap = 83.60 %
class_id = 26, name = mom_to_mom_butternut_squash_pear, ap = 95.71 %
class_id = 27, name = pop_tartarts_strawberry, ap = 95.70 %
class_id = 28, name = quaker_big_chewy_chocolate_chip, ap = 74.60 %
class_id = 29, name = spam, ap = 56.44 %
class_id = 30, name = coffee_mate_french_vanilla, ap = 96.32 %
class_id = 31, name = pepperidge_farm_milk_chocolate_macadamia_cookies, ap = 87.99 %
class_id = 32, name = kitkat_king_size, ap = 75.14 %
class_id = 33, name = snickers, ap = 1.02 %
class_id = 34, name = toblerone_milk_chocolate, ap = 82.28 %
class_id = 35, name = clif_z_bar_chocolate_chip, ap = 97.37 %
class_id = 36, name = nature_valley_crunchy_oats_n_honey, ap = 100.00 %
class_id = 37, name = ritz_crackers, ap = 98.36 %
class_id = 38, name = palmlive_orange, ap = 86.36 %
class_id = 39, name = crystal_hot_sauce, ap = 87.92 %
class_id = 40, name = tapatio_hot_sauce, ap = 78.41 %
class_id = 41, name = nabisco_nilla_wafers, ap = 97.69 %
class_id = 42, name = pepperidge_farm_milano_cookies_double_chocolate, ap = 90.33 %
class_id = 43, name = campbells_chicken_noodle_soup, ap = 100.00 %
class_id = 44, name = frappuccino_coffee, ap = 100.00 %
class_id = 45, name = chewy_dins_chocolate_chips, ap = 77.22 %
```

```
for thresh = 0.24, precision = 0.84, recall = 0.81, F1-score = 0.83
for thresh = 0.24, TP = 2411, FP = 450, FN = 548, average IoU = 66.30 %

mean average precision (mAP) = 0.878705, or 87.87 %

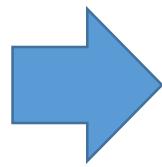
class_id = 46, name = dove_chocolate, ap = 100.00 %
class_id = 47, name = dove_white, ap = 99.64 %
class_id = 48, name = david_sunflower_seeds, ap = 100.00 %
class_id = 49, name = monster_energy, ap = 63.64 %
class_id = 50, name = act_iit_butter_lovers_popcorn, ap = 91.62 %
class_id = 51, name = coca_cola_glass_bottle, ap = 87.92 %
class_id = 52, name = twix, ap = 81.82 %
for thresh = 0.24, precision = 0.84, recall = 0.81, F1-score = 0.83
for thresh = 0.24, TP = 2411, FP = 450, FN = 548, average IoU = 66.30 %

mean average precision (mAP) = 0.878705, or 87.87 %
Total Detection time: 27.000000 Seconds
(base) truongnx@marlin:~/atx2023/skeleton$
```

# Quantization

```
float input_quant_multiplier[TOTAL_CALIB_LAYER] = {  
    8, //conv 0  
    8, //conv 1  
    8, //conv 2  
    8, //conv 4  
    8, //conv 5  
    8, //conv 7  
    8, //conv 10  
    8, //conv 12  
    8, //conv 13  
    8, //conv 15  
    8, //conv 18  
    8, //conv 20  
    8, //conv 21  
    8, //conv 23  
    8, //conv 26  
    8, //conv 27  
    8, //conv 30  
    8}; //conv 33  
  
float weight_quant_multiplier[TOTAL_CALIB_LAYER] = {  
    16, //conv 0  
    128, //conv 1  
    128, //conv 2  
    128, //conv 4  
    128, //conv 5  
    128, //conv 7  
    128, //conv 10  
    128, //conv 12  
    128, //conv 13  
    128, //conv 15  
    128, //conv 18  
    128, //conv 20  
    128, //conv 21  
    128, //conv 23  
    128, //conv 26  
    128, //conv 27  
    128, //conv 30  
    128}; //conv 33
```

87.87%  
→ 26.15%



```
for thresh = 0.24, precision = 0.80, recall = 0.00, F1-score = 0.01  
for thresh = 0.24, TP = 8, FP = 2, FN = 2951, average IoU = 56.19 %  
  
mean average precision (mAP) = 0.261461, or 26.15 %  
Total Detection Time: 26.000000 Seconds
```

```
class_id = 9, name = listerine_green, ap = 75.54 %  
class_id = 10, name = mahatma_rice, ap = 19.02 %  
class_id = 11, name = white_rain_body_wash, ap = 35.86 %  
class_id = 12, name = pringles_bbq, ap = 55.61 %  
class_id = 13, name = cheeze_it, ap = 67.39 %  
class_id = 14, name = hersheys_bar, ap = 42.05 %  
class_id = 15, name = redbull, ap = 18.18 %  
class_id = 16, name = mom_to_mom_sweet_potato_corn_apple, ap = 24.68 %  
class_id = 17, name = a1_steak_sauce, ap = 1.01 %  
class_id = 18, name = jif_creamy_peanut_butter, ap = 27.27 %  
class_id = 19, name = cinnamon_toast_crunch, ap = 3.14 %  
class_id = 20, name = arm_hammer_baking_soda, ap = 9.09 %  
class_id = 21, name = dr_pepper, ap = 18.18 %  
class_id = 22, name = haribo_gold_bears_gummi_candy, ap = 33.71 %  
class_id = 23, name = bulls_eye_bbq_sauce_original, ap = 17.17 %  
class_id = 24, name = reeses_pieces, ap = 45.16 %  
class_id = 25, name = clif_crunch_peanut_butter, ap = 15.64 %  
class_id = 26, name = mom_to_mom_butternut_squash_pear, ap = 48.68 %  
class_id = 27, name = pop_tartarts_strawberry, ap = 44.99 %  
class_id = 28, name = quaker_big_chewy_chocolate_chip, ap = 29.81 %  
class_id = 29, name = spam, ap = 19.59 %  
class_id = 30, name = coffee_mate_french_vanilla, ap = 9.09 %  
class_id = 31, name = pepperidge_farm_milk_chocolate_macadamia_cookies, ap = 22.51 %  
class_id = 32, name = kitkat_king_size, ap = 9.09 %  
class_id = 33, name = snickers, ap = 0.00 %  
class_id = 34, name = toblerone_milk_chocolate, ap = 0.00 %  
class_id = 35, name = clif_z_bar_chocolate_chip, ap = 57.21 %  
class_id = 36, name = nature_valley_crunchy_oats_n_honey, ap = 49.98 %  
class_id = 37, name = ritz_crackers, ap = 24.98 %  
class_id = 38, name = palmolive_orange, ap = 54.55 %  
class_id = 39, name = crystal_hot_sauce, ap = 9.09 %  
class_id = 40, name = tapatio_hot_sauce, ap = 18.18 %  
class_id = 41, name = nabisco_nilla_wafers, ap = 26.88 %  
class_id = 42, name = pepperidge_farm_milano_cookies_double_chocolate, ap = 12.99 %  
class_id = 43, name = campbells_chicken_noodle_soup, ap = 18.18 %  
class_id = 44, name = frappuccino_coffee, ap = 33.95 %  
  
for thresh = 0.24, precision = 0.80, recall = 0.00, F1-score = 0.01  
for thresh = 0.24, TP = 8, FP = 2, FN = 2951, average IoU = 56.19 %  
  
mean average precision (mAP) = 0.261461, or 26.15 %  
Total Detection Time: 26.000000 Seconds  
class_id = 55, name = davio_sunflower_seeds, ap = 29.01 %  
class_id = 56, name = monster_energy, ap = 0.00 %  
class_id = 57, name = act_iit_butter_lovers_popcorn, ap = 7.79 %  
class_id = 58, name = coca_cola_glass_bottle, ap = 14.18 %  
class_id = 59, name = twix, ap = 25.17 %  
for thresh = 0.24, precision = 0.80, recall = 0.00, F1-score = 0.01  
for thresh = 0.24, TP = 8, FP = 2, FN = 2951, average IoU = 56.19 %  
  
mean average precision (mAP) = 0.261461, or 26.15 %  
Total Detection Time: 26.000000 Seconds  
(base) truongnx@marlin:~/aix2023/skeleton$
```

# Quantization

```
float input_quant_multiplier[TOTAL_CALIB_LAYER] = {  
    128, //conv 0  
    8, //conv 1  
    8, //conv 2  
    8, //conv 4  
    8, //conv 5  
    8, //conv 7  
    8, //conv 10  
    8, //conv 12  
    8, //conv 13  
    8, //conv 15  
    8, //conv 18  
    8, //conv 20  
    8, //conv 21  
    8, //conv 23  
    8, //conv 26  
    8, //conv 27  
    8, //conv 30  
}; //conv 33  
  
float weight_quant_multiplier[TOTAL_CALIB_LAYER] = {  
    16, //conv 0  
    128, //conv 1  
    128, //conv 2  
    128, //conv 4  
    128, //conv 5  
    128, //conv 7  
    128, //conv 10  
    128, //conv 12  
    128, //conv 13  
    128, //conv 15  
    128, //conv 18  
    128, //conv 20  
    128, //conv 21  
    128, //conv 23  
    128, //conv 26  
    128, //conv 27  
    128, //conv 30  
}; //conv 33
```

Change calibration for the first layer

87.87%  
→ 26.15%  
→ 41.02%



```
class_id = 9, name = listerine_green, ap = 98.22 %  
class_id = 10, name = mahatma_rice, ap = 52.13 %  
class_id = 11, name = white_rain_body_wash, ap = 25.81 %  
class_id = 12, name = pringles_bbq, ap = 67.61 %  
class_id = 13, name = cheeze_it, ap = 98.41 %  
class_id = 14, name = hersheys_bar, ap = 38.46 %  
class_id = 15, name = redbull, ap = 9.09 %  
class_id = 16, name = mom_to_mom_sweet_potato_corn_apple, ap = 32.06 %  
class_id = 17, name = al_steak_sauce, ap = 9.09 %  
class_id = 18, name = jif_creamy_peanut_butter, ap = 27.27 %  
class_id = 19, name = cinnamon_toast_crunch, ap = 76.12 %  
class_id = 20, name = arm_hammer_baking_soda, ap = 9.09 %  
class_id = 21, name = dr_pepper, ap = 26.45 %  
class_id = 22, name = haribo_gold_bears_gummi_candy, ap = 66.26 %  
class_id = 23, name = bulls_eye_bbq_sauce_original, ap = 27.27 %  
class_id = 24, name = reeses_pieces, ap = 76.10 %  
class_id = 25, name = clif_crunch_peanut_butter, ap = 13.58 %  
class_id = 26, name = mom_to_mom_butternut_squash_pear, ap = 66.02 %  
class_id = 27, name = pop_tartarts_strawberry, ap = 53.91 %  
class_id = 28, name = quaker_big_chewy_chocolate_chip, ap = 74.16 %  
class_id = 29, name = spam, ap = 15.76 %  
class_id = 30, name = coffee_mate_french_vanilla, ap = 23.64 %  
class_id = 31, name = pepperidge_farm_milk_chocolate_macadamia_cookies, ap = 11.04 %  
class_id = 32, name = kitkat_king_size, ap = 24.68 %  
class_id = 33, name = snickers, ap = 0.00 %  
class_id = 34, name = toblerone_milk_chocolate, ap = 3.03 %  
class_id = 35, name = clif_z_bar_chocolate_chip, ap = 77.79 %  
class_id = 36, name = nature_valley_crunchy_oats_n_honey, ap = 66.30 %  
class_id = 37, name = ritz_crackers, ap = 62.06 %  
class_id = 38, name = palmlive_orange, ap = 72.73 %  
class_id = 39, name = crystal_hot_sauce, ap = 16.67 %  
class_id = 40, name = tapatio_hot_sauce, ap = 31.97 %  
class_id = 41, name = nabisco_nilla_wafers, ap = 54.86 %  
class_id = 42, name = pepperidge_farm_milano_cookies_double_chocolate, ap = 4.98 %  
class_id = 43, name = campbells_chicken_noodle_soup, ap = 27.27 %  
class_id = 44, name = frappuccino_coffee, ap = 80.90 %  
class_id = 45, name = chewy_dips_chocolate_chip, ap = 27.57 %  
class_id = 46, name = chewy_dips_peanut_butter, ap = 75.16 %  
class_id = 47, name = nature_valley_fruit_and_nut, ap = 42.97 %  
class_id = 48, name = cheerios, ap = 62.60 %  
class_id = 49, name = lindt_excellence_cocoa_dark_chocolate, ap = 32.52 %  
class_id = 50, name = hersheys_symphony, ap = 12.81 %  
class_id = 51, name = campbells_chunky_classic_chicken_noodle, ap = 59.98 %  
  
for thresh = 0.24, precision = 1.00, recall = 0.02, F1-score = 0.04  
for thresh = 0.24, TP = 53, FP = 0, FN = 2906, average IoU = 76.66 %  
  
mean average precision (mAP) = 0.410209, or 41.02 %  
  
class_id = 59, name = twix, ap = 67.51 %  
for thresh = 0.24, precision = 1.00, recall = 0.02, F1-score = 0.04  
for thresh = 0.24, TP = 53, FP = 0, FN = 2906, average IoU = 76.66 %  
  
mean average precision (mAP) = 0.410209, or 41.02 %  
Total Detection Time: 26.000000 Seconds  
(base) truongnx@marlin:~/aix2023/skeleton$
```

# Incoming ...

- AIX2023 Software Development Toolkit (SDK) Installation
- AIX2023 SDK Programming Guideline
- AIX2023 Integration Guideline
- Materials and Video lectures from the AIX2022

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