RZ/V2L, RZ/V2M, RZ/V2MA AI IMPLEMENTATION GUIDE

MMPose HRNet

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RENESAS ELECTRONICS CORPORATION

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Overview

This document explains the contents of AI Implementation Guide Get Started document with HRNet pre-trained model provided by MMPose framework (hereafter, MMPose HRNet).

Please read Get Started document in advance.

This document uses following documents and files.

名称	Filename	Details
Get Started Document	r11an0616ej0720-rzv-ai-imp-getstarted.pdf	Document for guiding how to make AI Implementation Guide environment and how to develop AI application.
Get Started Source Code	rzv_ai-implementation-guide_ver7.20.tar.gz	Source code used throughout the overall AI Implementation Guide.
Document for MMPose HRNet	r11an0621ej0720-rzv-ai-imp-hrnet.pdf	This document. Document for guiding the instruction for MMPose HRNet model.
Source Code for MMPose HRNet	mmpose_hrnet_ver7.20.tar.gz	Source code and example output used in the Document for MMPose HRNet.

MMPose

https://github.com/open-mmlab

Flow of Guide

Program made in the Step

Output of previous step

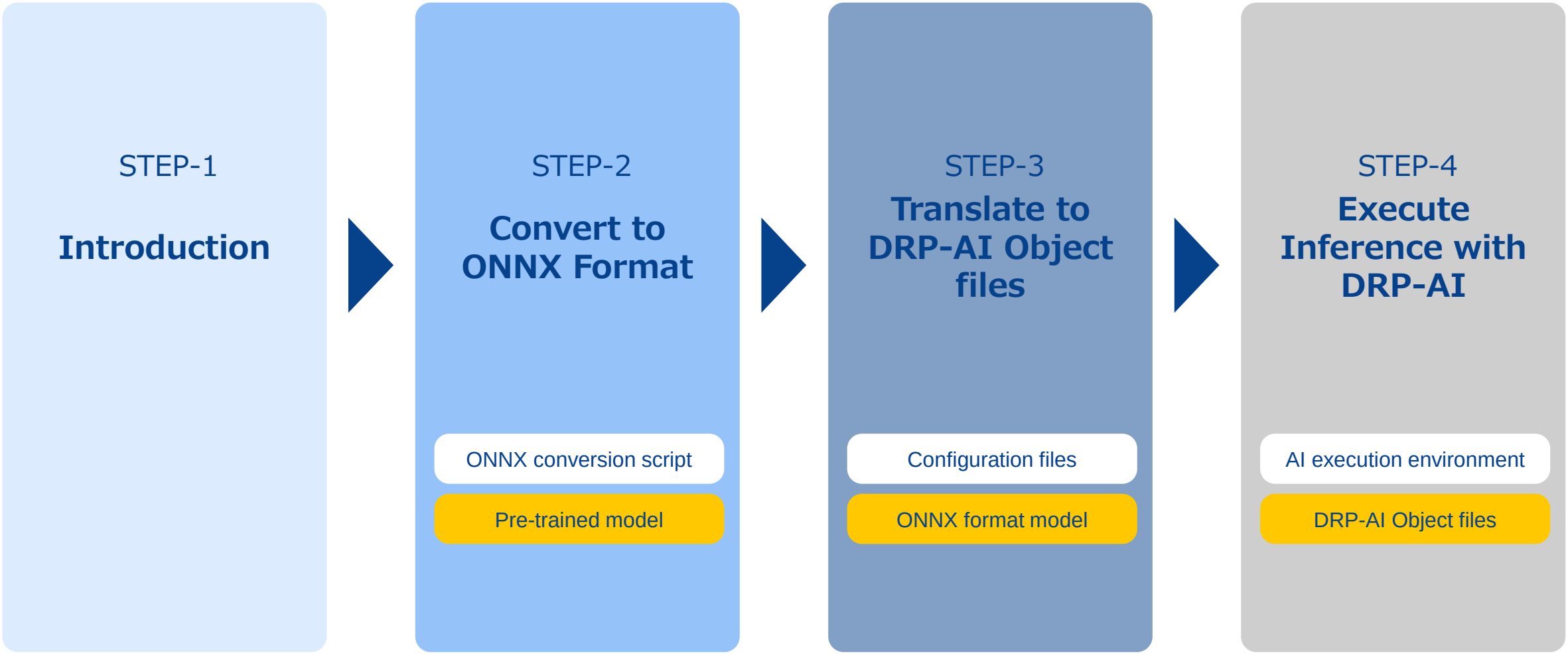


Table of Contents

Program made in the Step

Output of previous step

STEP-1

Introduction

STEP-2

Convert to ONNX Format

ONNX conversion script

Pre-trained model

STEP-3

Translate to DRP-AI Object files

Configuration files

ONNX format model

STEP-4

Execute Inference with DRP-AI

AI execution environment

DRP-AI Object files

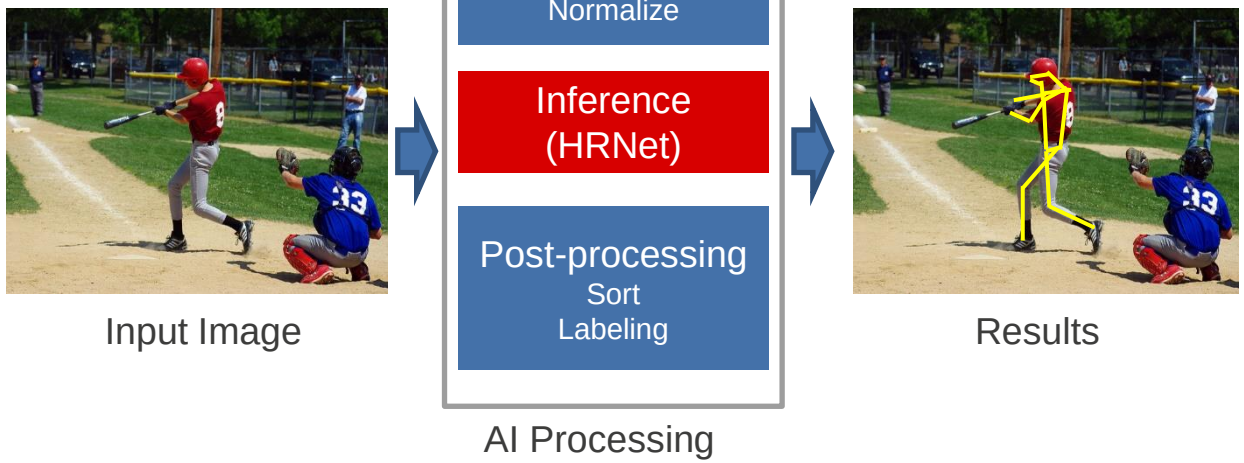
HRNet

This document uses the HRNet model provided by MMPose framework.

HRNet(**H**igh-**R**esolution **Net**work) is an image recognition neural network for Human Pose Estimation.

HRNet starts from high-resolution sub-network and adds low-resolution sub-network as the network goes deeper.

By training these sub-network in parallel, HRNet achieves more accurate pose estimation.



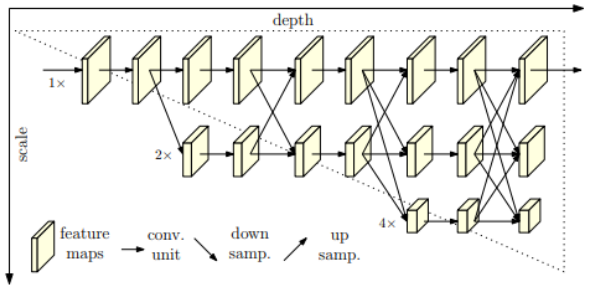


Figure 1. Illustrating the architecture of the proposed HRNet. It consists of parallel high-to-low resolution subnetworks with repeated information exchange across multi-resolution subnetworks (multi-scale fusion). The horizontal and vertical directions correspond to the depth of the network and the scale of the feature maps, respectively.

(Cite) Deep High-Resolution Representation Learning for Human Pose Estimation
https://arxiv.org/pdf/1902.09212.pdf

(Paper) Deep High-Resolution Representation Learning for Human Pose Estimation https://arxiv.org/pdf/1902.09212.pdf

Top-down vs Bottom-up

In 2-D Human Pose Estimation for multiple target, there are 2 approaches, which are Top-down approach and Bottom-up approach.

Top-down approach detects the human in the input image first, and then estimate its pose for each human.

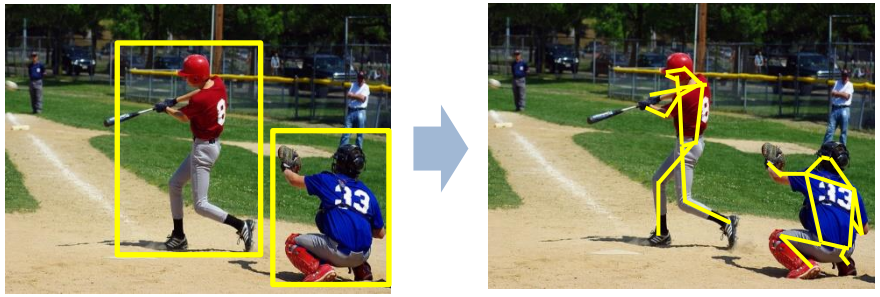
Bottom-up approach detects the all joint (key point) available first, and then groups the key point to each human.

HRNet is Top-down approach Pose Estimation model, which assumes the human detection is already finished.

Therefore, this document assumes the human detection is done and explains how to use the HRNet as a single-person human pose detection model.

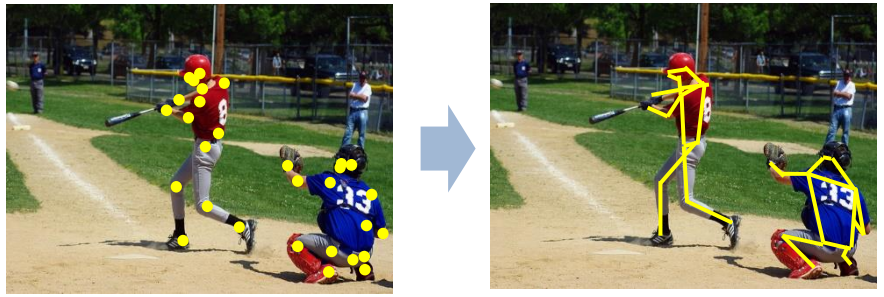
Top-down

Detect human and then detect key points for each human.



Bottom-up

Detect key points and then group them to each human.



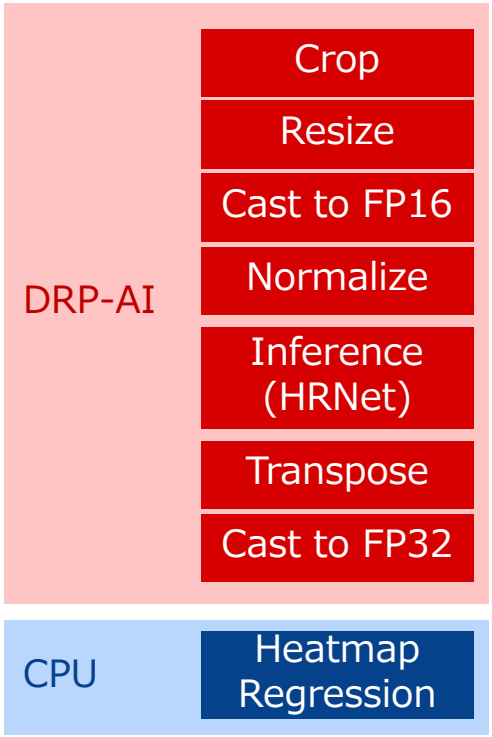
(Paper) Deep High-Resolution Representation Learning for Human Pose Estimation https://arxiv.org/pdf/1902.09212.pdf

[Reference] HRNet on DRP-AI

Following is the example of HRNet model inference on DRP-AI.

The input image is 640x480 in BGR.

Operators that are not supported by DRP-AI need to be computed by CPU.



<Pre-processing>
Crop : Input image size (640x480 BGR) to portrait image size (270x480 BGR).
Resize : Image size (270x480 BGR) to HWC tensor size (192x256x3).
Cast to fp16 : Cast to fp16 from int8 for DRP-AI processing.
Normalize: Normalized using 'mean' and 'std'.

<Post-processing>
Transpose : HWC (64x48x17) to CHW (17x64x48).
Cast to fp32

[Reference] MMPose & PyTorch

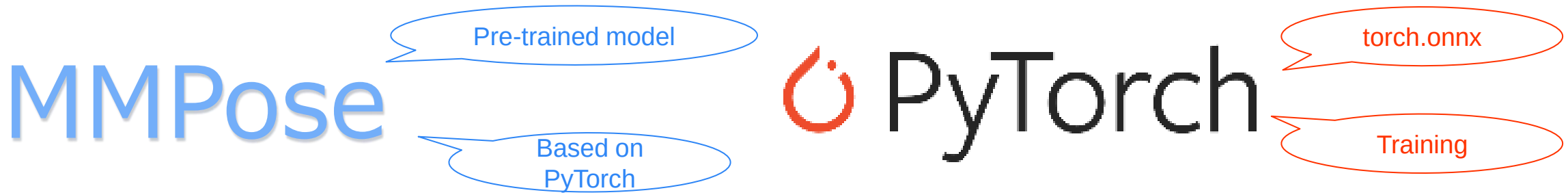
This document will use the pre-trained model provided by MMPose.

MMPose is a toolbox for pose estimation based on PyTorch framework.

It uses PyTorch training function, onnx conversion function (torch.onnx), etc. to enable the pose estimation model training/onnx conversion.

See PyTorch official document (https://pytorch.org/docs/1.12/) to learn more about the PyTorch.

See MMPose official website (https://github.com/open-mmlab/mmpose) to learn more about the MMPose.



Necessary Environment

Following are the necessary environment for each STEP.

See the Get Started Document for how to build the environment.

<ONNX conversion env.>

MMPose PyTorch *1

Used in the following step.
- STEP-2: Convert to ONNX Format

<DRP-AI Translator env.>

DRP-AI Translator

Used in the following step.
- STEP-3: Translate to DRP-AI Object files

*1 PyTorch, the PyTorch logo and any related marks are trademarks of Facebook, Inc.

Necessary Files

Source codes used in this document are provided in mmpose_hrnet_ver7.20.tar.gz.

- mmpose_hrnet_ver7.20
  - drpai_samples
    - onnx
    - hrnet_bmp

  Example of input files of DRP-AI Translator.
  Used in STEP-3.

  - mmpose
    - hrnet

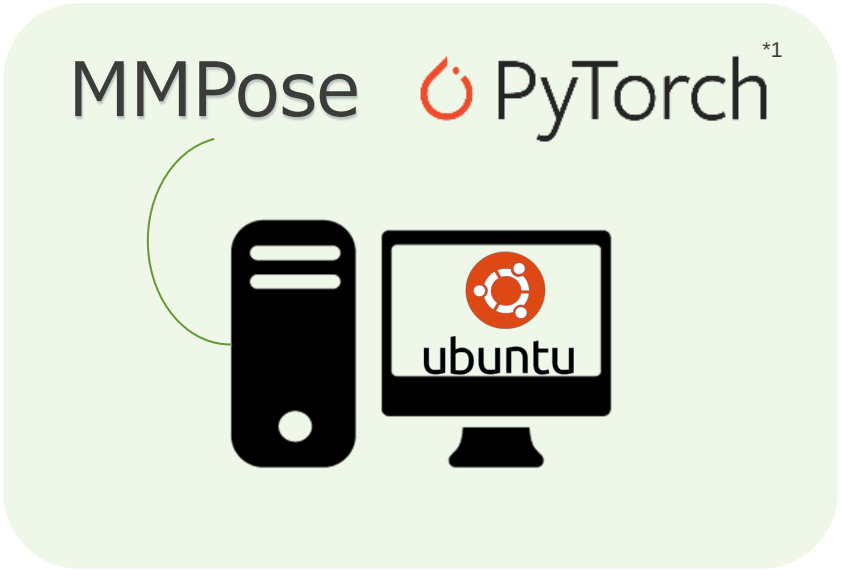
  ONNX conversion script and post-processing script.
  Used in STEP-2 and STEP-4.

[Additional Information] HRNet Training Environment

This guide will not explain about the training procedure of Deep Learning.

Please refer to the MMPose Official Website (https://github.com/open-mmlab/mmpose) to see how to train the model by own dataset, or how to customize the neural network.

<Training Env.>



*1 PyTorch, the PyTorch logo and any related marks are trademarks of Facebook, Inc.

STEP-1 Summary

STEP-1 explained the basic knowledge to implement AI model.

Please proceed to "STEP-2 Convert to ONNX Format".

Program made in the Step

Output of previous step

STEP-1

Introduction

STEP-2

Convert to ONNX Format

ONNX conversion script

Pre-trained model

STEP-3

Translate to DRP-AI Object files

Configuration files

ONNX format model

STEP-4

Execute Inference with DRP-AI

AI execution environment

DRP-AI Object files

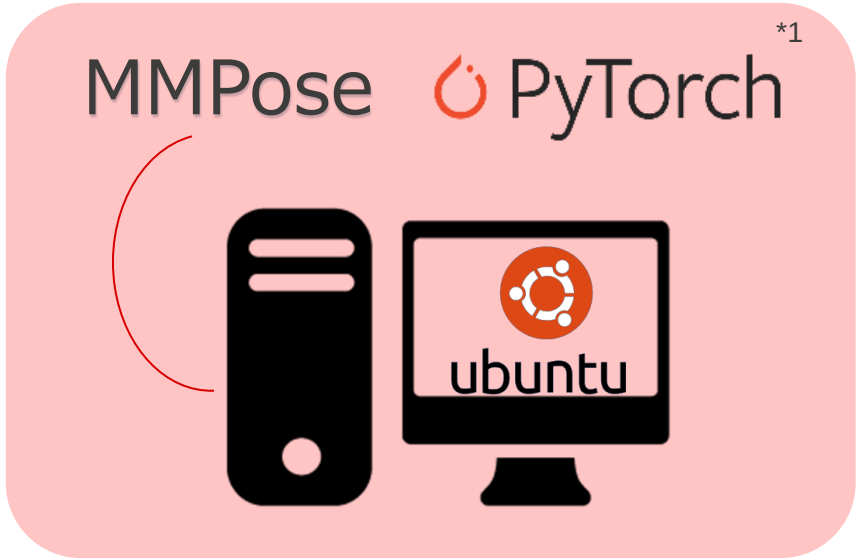
2.1: Convert to the ONNX Format

MMPose provides the pre-trained model structure and its weight parameter.

This STEP will explain the contents of Get Started Document "STEP-2 Convert to the ONNX Format" with HRNet model provided by MMPose.

Following is the necessary environment.

＜ONNX conversion env.＞



MMPose

Pre-trained HRNet model (COCO Dataset)

HRNet COCO Dataset Model:
https://mmpose.readthedocs.io/en/latest/papers/algorithms.html#topdown-heatmap-hrnet-on-coco

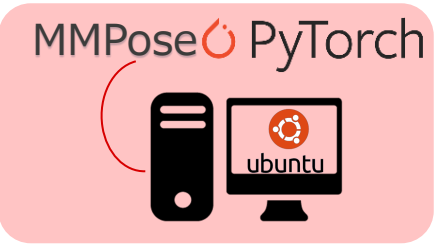
ONNX

Conversion from MMPose to ONNX

ONNX tutorials:
https://github.com/onnx/tutorials
MMPose official tutorial:
https://mmpose.readthedocs.io/en/latest/tutorials/5_export_model.html

*1 PyTorch, the PyTorch logo and any related marks are trademarks of Facebook, Inc.

<ONNX conversion env.>



2.2: Make the ONNX Conversion Environment

This section will explain the instruction with the following assumption

- Constructed the ONNX conversion environment
  according to Get Started Document "STEP-2.2: Make the ONNX Conversion Environment".

Please check the following item.

1. Confirm the environment variable is registered properly. Green is the environment variable.

```
$ printenv WORK
```

If displayed as follows, the variable is correctly set.

```
<path to the working directory>/rzv_ai_work
```

2. Register the symbolic link. (This command must be executed when new terminal is opened.)

```
$ cd $WORK/mmpose
$ sudo python3 setup.py develop
```

2.3: Prepare the Necessary Files

This section will explain the instruction with the following assumption

- Extracted the necessary files
  according to Get Started Document "STEP-2.3: Prepare the Necessary Files".

Please run the following commands to prepare the necessary files for this document.

1. Move to the working directory. Green is the environment variable.

```
$ cd $WORK
```

2. Extract tar.gz file under the working directory.

```
$ tar xvzf <File path>/mmpose_hrnet_ver7.20.tar.gz -C $WORK
```

3. Check the working directory.

```
$ ls $WORK
```

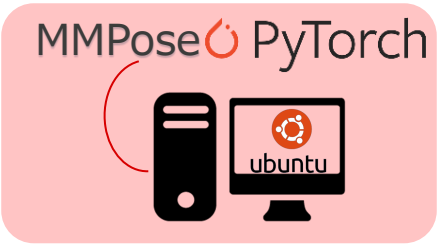
If displayed as follows, the package is correctly extracted.

```
drpai_samples    mmpose
```

"drpai_samples" includes sample codes and example output of DPR-AI Translator.

"mmpose" includes sample code for MMPose.

<ONNX conversion env.>



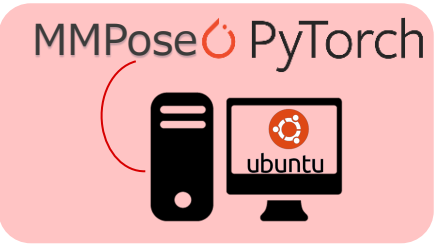
2.3: Prepare the Necessary Files

Please confirm that each directory configuration is as follows.

<ONNX conversion working directory ($WORK)>

- rzv_ai_work
  - drpai_samples
    - onnx
      - hrnet.onnx
    - hrnet_bmp
    - addrmap_in_linux.yaml
  - mmpose
    - hrnet
      - postprocess_hrnet.py
    - configs
    - demo
    - …

<ONNX conversion env.>



2.4: Convert AI Model to ONNX Format

Since MMPose uses PyTorch onnx conversion function in its script,
following NN model structure and its weight parameter are required as explained in the Get Started Document "STEP-2.4: Convert AI Model to ONNX Format".

PyTorch *1

NN model structure
`*.py file`

NN model weight parameter
`*.pth file`

*1 PyTorch, the PyTorch logo and any related marks are trademarks of Facebook, Inc.

MMPose onnx conversion script converts these model structure and weight parameter to ONNX format using the following PyTorch function.

```
torch.onnx.export(model, …)
```

ONNX tutorials: https://github.com/onnx/tutorials

PyTorch official tutorial: https://pytorch.org/tutorials/advanced/super_resolution_with_onnxruntime.html

MMPose official tutorial: https://mmpose.readthedocs.io/en/latest/tutorials/5_export_model.html

2.4: Convert AI Model to ONNX Format

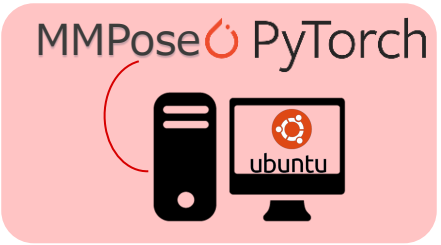
This document will use the following script to convert HRNet model provided by MMPose into ONNX format.

These files are already downloaded to MMPose environment when installing the MMPose.

This document will modify the ONNX conversion script in order to make DRP-AI Translator execution easier.

Name	Filename	Usage	Source
ONNX conversion script	pytorch2onnx.py	MMPose-ONNX conversion	Provided by MMPose
HRNet Model Structure	hrnet_w32_coco_256x192.py	MMPose-ONNX conversion	Provided by MMPose
HRNet Weight Parameter	hrnet_w32_coco_256x192-c78dce93_20200708.pth	MMPose-ONNX conversion	Provided by MMPose

<ONNX conversion env.>



2.4: Convert AI Model to ONNX Format

1. Prepare the ONNX conversion script.

Path: *$WORK/mmpose/tools/deployment/pytorch2onnx.py*

<Before>

```
...
def pytorch2onnx(model,
                 input_shape,
                 opset_version=11,
                 show=False,
                 output_file='tmp.onnx',
                 verify=False):
...

    register_extra_symbolics(opset_version)
    torch.onnx.export(
        model,
        one_img,
        output_file,
        export_params=True,
        keep_initializers_as_inputs=True,
        verbose=show,
        opset_version=opset_version)
```

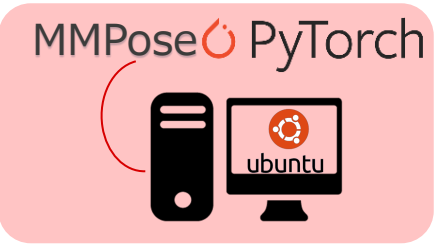
<After>

```
...
def pytorch2onnx(model,
                 input_shape,
                 opset_version=11,
                 show=False,
                 output_file='tmp.onnx',
                 verify=False):
...

    input_names=["input1"]
    output_names=["output1"]

    register_extra_symbolics(opset_version)
    torch.onnx.export(
        model,
        one_img,
        output_file,
        export_params=True,
        keep_initializers_as_inputs=True,
        verbose=show,
        opset_version=opset_version,
        input_names=input_names,
        output_names=output_names)
```

Names specified here will be used in STEP-3.
input_names: Input name of first layer of the model
output_names: Output name of first layer of the model

2.4: Convert AI Model to ONNX Format

<ONNX conversion env.>



2. Register the path to model structure file as an environment variable.

```
$ export NN=configs/body/2d_kpt_sview_rgb_img/topdown_heatmap/coco/hrnet_w32_coco_256x192.py
```

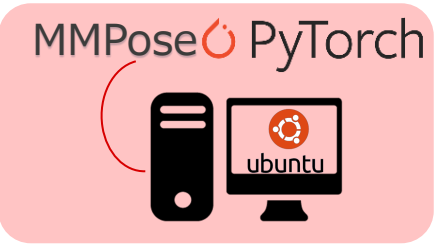
3. Register the URL of weight file as an environment variable.

```
$ export WEIGHT=https://download.openmmlab.com/mmpose/top_down/hrnet/hrnet_w32_coco_256x192-c78dce93_20200708.pth
```

4. Register the output filename as an environment variable.

```
$ export OUTPUT=hrnet.onnx
```

<ONNX conversion env.>



2.4: Convert AI Model to ONNX Format

5. Move to the ONNX conversion working directory.

```
$ cd $WORK/mmpose
```

6. Run the onnx conversion script.

```
$ python3 tools/deployment/pytorch2onnx.py $NN $WEIGHT --opset-version 11 --shape 1 3 256 192 --output-file $OUTPUT
```

Note

Although DRP-AI Translator's supported ONNX opset version is 12, MMPose does not support opset version 12.
Therefore, this document specifies opset version as 11.

If displayed as follows, the model is successfully converted.

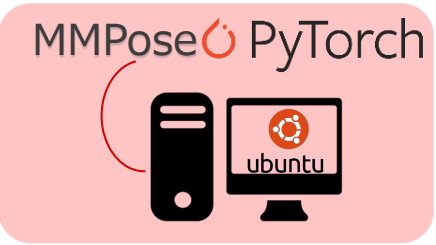
```
Successfully exported ONNX model: hrnet.onnx
```

A warning occurs as below, but there is no problem.

```
/mmcv/cnn/bricks/transformer.py:33: UserWarning: Fail to import ``MultiScaleDeformableAttention`` from ``mmcv.ops.multi_scale
_deform_attn``, You should install ``mmcv-full`` if you need this module.
tools/deployment/pytorch2onnx.py:151: UserWarning: DeprecationWarning: This tool will be deprecated in future. Welcome to use
 the unified model deployment toolbox MMDeploy: https://github.com/open-mmlab/mmdeploy
/mmcv/onnx/symbolic.py:481: UserWarning: DeprecationWarning: This function will be deprecated in future. Welcome to use the u
nified model deployment toolbox MMDeploy: https://github.com/open-mmlab/mmdeploy
```

If error occurred, please register the symbolic link as explained in "STEP-2.2 Make the ONNX Conversion Environment" and try the onnx conversion again.

<ONNX conversion env.>



2.4: Convert AI Model to ONNX Format

7. Check that *onnx* file is generated under *mmpose* directory.

```
$ ls $WORK/mmpose
```

Check the *hrnet.onnx* file is generated.

```
hrnet.onnx  ...
```

STEP-2 Summary

In this chapter, MMPose HRNet model has been converted to ONNX format model.

Next, we will use the converted ONNX model to run the DRP-AI Translator.

Please proceed to the next step "STEP-3 Translate to DRP-AI Object files".

Program made in the Step

Output of previous step

STEP-1

Introduction

STEP-2

Convert to ONNX Format

ONNX conversion script

Pre-trained model

STEP-3

Translate to DRP-AI Object files

Configuration files

ONNX format model

STEP-4

Execute Inference with DRP-AI

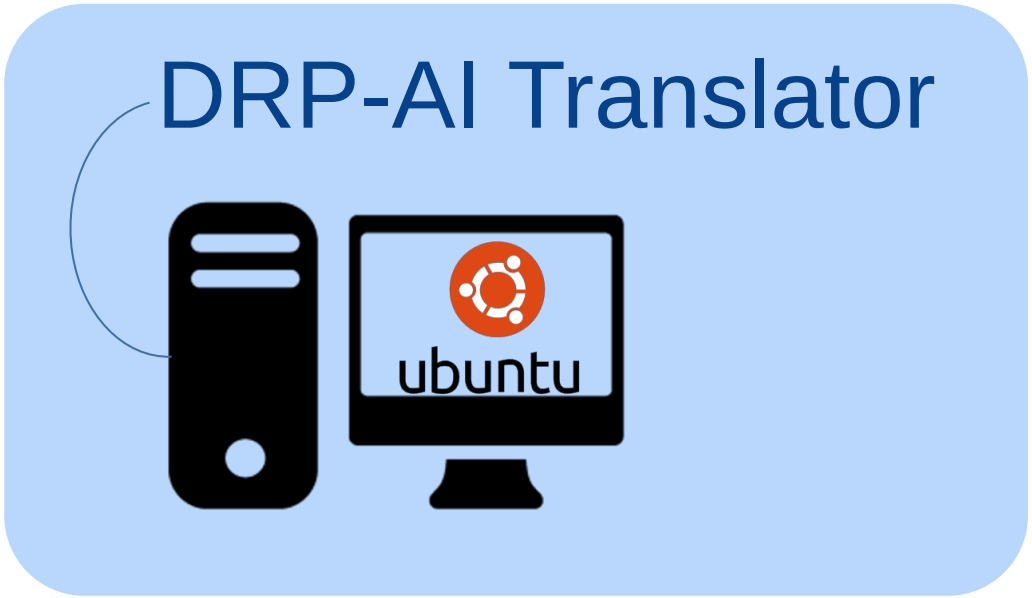
AI execution environment

DRP-AI Object files

Translate to DRP-AI Object files

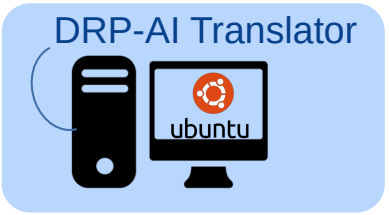
This step will explain how to translate the ONNX format model created in STEP-2 to the DRP-AI Object files.

<DRP-AI Translator env.>



ONNX format model created in STEP-2

<DRP-AI Translator env.>



3.1: Make the DRP-AI Translator Environment

This section will explain the instruction with the following assumption

- Constructed the DRP-AI Translator environment
  according to Get Started Document "STEP-3.1: Make the DRP-AI Translator Environment".

Please check following items.

1. Confirm the environment variable for working directory is registered properly. Green is the environment variable.

```
$ printenv WORK
```

If displayed as follows, the variable is correctly set.

```
<path to the working directory>/rzv_ai_work
```

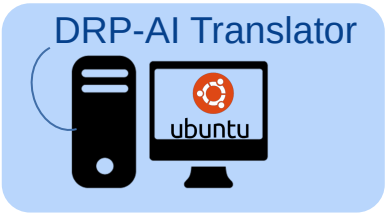
2. Confirm the environment variable for DRP-AI Translator working directory is registered properly.

```
$ printenv DRPAI
```

If displayed as follows, the variable is correctly set.

```
<$WORK Path>/drp-ai_translator_release
```

<DRP-AI Translator env.>



3.2: Check the File Configuration

Please confirm that each directory configuration is as follows.

<ONNX conversion working directory ($WORK)>

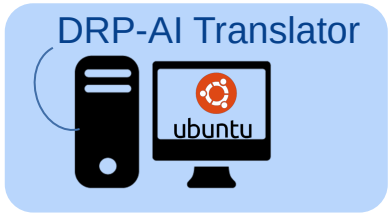
- *rzv_ai_work*
  - *drpai_samples*
    - *onnx*
      - *hrnet.onnx*
    - *hrnet_bmp*
    - *addrmap_in_linux.yaml*
  - *mmpose*
    - *hrnet*
    - …
  - *drp-ai_translator_release*

<DRP-AI Translator working directory ($DRPAI)>

- *drp-ai_translator_release*
  - *DRP-AI_translator*
  - *onnx*
  - *output*
  - *UserConfig*
  - *run_DRP-AI_translator_V2M.sh*
  - *run_DRP-AI_translator_V2L.sh*

To see the details of DRP-AI Translator directory, please refer to the Get Started Document.

<DRP-AI Translator env.>



3.3: Prepare the ONNX File

In this section, we will prepare the ONNX file which is necessary for DRP-AI Translator.

- *drp-ai_translator_release*
  - *…*
  - *onnx*
    - *hrnet.onnx*
  - *UserConfig*
    - *addrmap_in_hrnet.yaml*
    - *prepost_hrnet.yaml*

1. Copy the *onnx* file created in STEP-2 to the *onnx* directory.

```
$ cp -v $WORK/mmpose/hrnet.onnx $DRPAI/onnx/
```

2. Check the *onnx* directory.

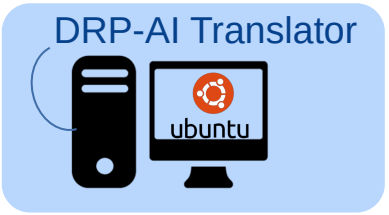
```
$ ls $DRPAI/onnx/
```

Check that there is *hrnet.onnx* file.

```
hrnet.onnx  tiny_yolov2.onnx  yolov2.onnx
```

└ These two files are sample models of DRP-AI Translator.

<DRP-AI Translator env.>



3.4: Prepare the Address Map Definition File

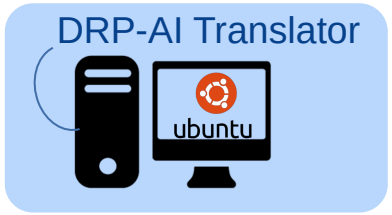
In this section, we will prepare the address map definition file which is necessary for DRP-AI Translator.

- *drp-ai_translator_release*
  - *…*
  - *onnx*
    - *hrnet.onnx*
  - *UserConfig*
    - *addrmap_in_hrnet.yaml*
    - *prepost_hrnet.yaml*

This section explains the actual commands only.

The start address need to be changed.

To see more details of the address map definition file,
please refer to "STEP-3.4: Prepare the Address Map Definition File" in the Get Started Document.



3.4: Prepare the Address Map Definition File

For address map definition file, we will use the *addrmap_in_linux.yaml* provided in *rzv_ai-implementation-guide_ver7.20.tar.gz*.

We need to rename it according to the address map definition file naming rule.

hrnet.onnx

addrmap_in_hrnet.yaml

1. Copy *addrmap_in_linux.yaml* to the *drp-ai_translator_release/UserConfig* directory.

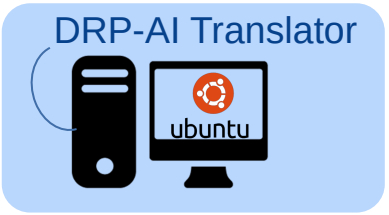
```
$ cp -v $WORK/drpai_samples/addrmap_in_linux.yaml $DRPAI/UserConfig
```

2. Rename *addrmap_in_linux.yaml* to *addrmap_in_hrnet.yaml.*

```
$ cd $DRPAI/UserConfig
```

```
$ mv -v ./addrmap_in_linux.yaml ./addrmap_in_hrnet.yaml
```

<DRP-AI Translator env.>



3.5: Prepare the Pre/Postprocessing Definition File

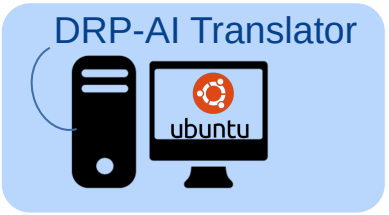
In this section, we will prepare the pre/postprocessing definition file which is necessary for DRP-AI Translator.

- *drp-ai_translator_release*
  - *…*
  - *onnx*
    - *hrnet.onnx*
  - *UserConfig*
    - *addrmap_in_hrnet.yaml*
    - *prepost_hrnet.yaml*

This section explains the actual commands only.

To see more details of the pre/postprocessing definition file,
please refer to "STEP-3.5: Prepare the Pre/Postprocessing Definition File" in the Get Started Document.

<DRP-AI Translator env.>



3.5: Prepare the Pre/Postprocessing Definition File

It is easier to make the pre/postprocessing definition file based on the sample file included in DRP-AI Translator.

The sample file is under the *UserConfig/sample* directory.

- *drp-ai_translator_release*
  - *DRP-AI_translator*
    - …
  - *UserConfig*
    - *sample*
      - *prepost_resnet50v1.yaml*
      - *prepost_tiny_yolov2.yaml*
      - *prepost_vgg16.yaml*
      - *prepost_yolov2.yaml*

Postprocessing for MMPose HRNet is similar to the definition stated in the *prepost_tiny_yolov2.yaml.* Modify this file to prepare the pre/postprocessing definition file for MMPose HRNet.

NOTE:

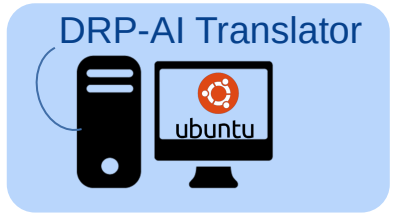
Please store all customized yaml files under the *UserConfig* directory

1. Copy *prepost_tiny_yolov2.yaml* to the *UserConfig* directory.

```
$ cd $DRPAI/UserConfig
```

```
$ cp -v ./sample/prepost_tiny_yolov2.yaml ./
```

<DRP-AI Translator env.>



3.5: Prepare the Pre/Postprocessing Definition File

Since DRP-AI Translator finds the pre/postprocessing definition file based on the ONNX file name, rename the sample pre/postprocessing definition file.

hrnet.onnx

prepost_hrnet.yaml

2. Rename *prepost_tiny_yolov2.yaml* to *prepost_hrnet.yaml.*

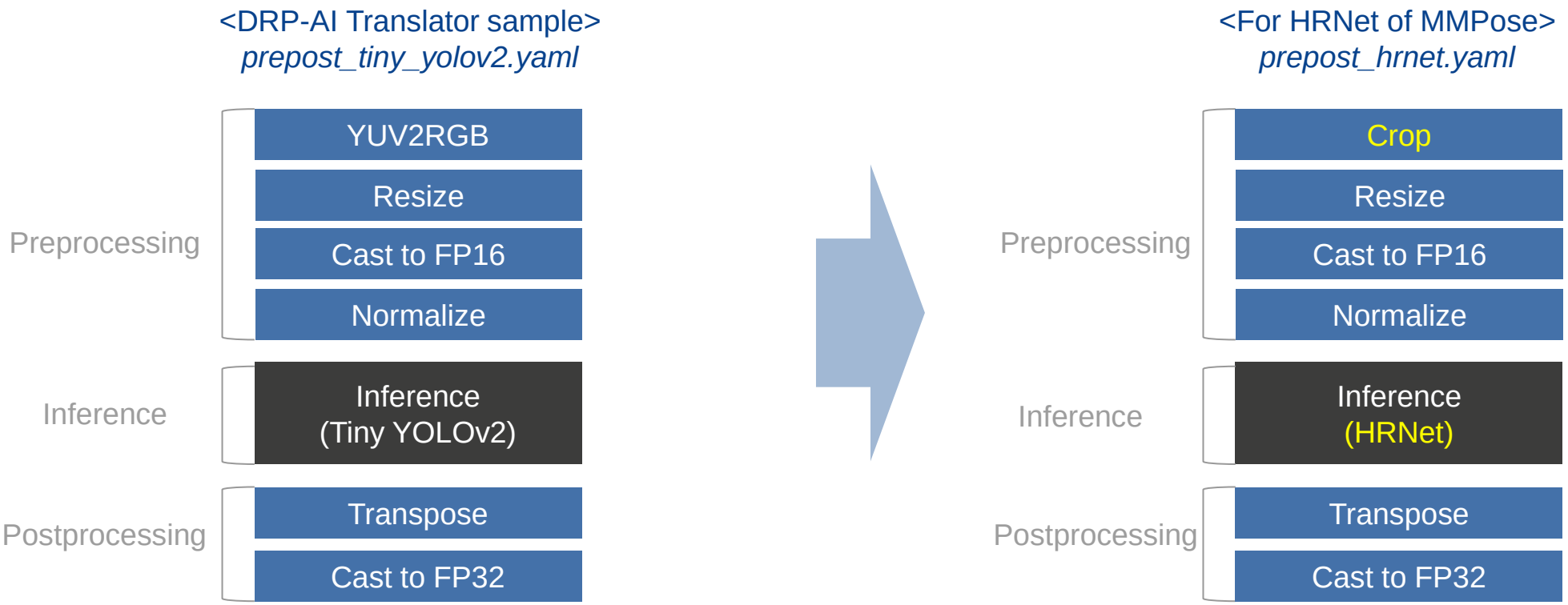
```
$ cd $DRPAI/UserConfig
```

```
$ mv -v ./prepost_tiny_yolov2.yaml ./prepost_hrnet.yaml
```

3.5: Prepare the Pre/Postprocessing Definition File

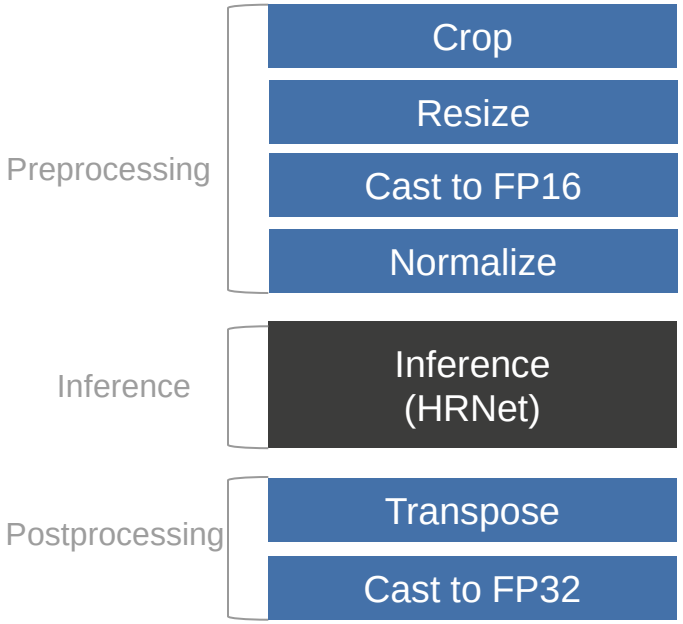
prepost_tiny_yolov2.yaml included in DRP-AI Translator is defined as shown in the left figure.

This section will explain how to rewrite the pre/postprocessing definition file for HRNet of MMPose shown in the right figure, which includes the modification of input data format from YUV to BGR.



3.5: Prepare the Pre/Postprocessing Definition File

<For HRNet of MMPose>
prepost_hrnet.yaml



Following items need to be rewritten to change the format based on the left figure.

(1) Set the input/output name of the model to the same name as the input/output layer name of the model named in STEP-2.

(2) Change the input data format for the preprocessing from YUY2 to BGR.

(3) Set the parameters of normalize to the training value.

(4) Change the input/output size of the model based on HRNet.

(5) Add the crop operator.

The correspondence of rewriting information and each definition is shown below.

Definitions of *prepost_hrnet.yaml*	
Input data definition	(1), (2), (4)
Output data definition	(1), (4)
Preprocessing definition	(1), (2), (3), (5)
Postprocessing definition	(1)

3.5: Prepare the Pre/Postprocessing Definition File

First, set the input/output name of the model to the same name as the input/output layer name of the model named in STEP-2.

The input name to the first layer of the model and the output name from the final layer of the model were defined by *pytorch2onnx.py* in "STEP-2.4: Convert AI Model to ONNX Format".

We will set this input name (*input1*) and the output name (*output1*) in each definition.

<pytorch2onnx.py After Modification>

```
42  ...
43  def pytorch2onnx(model,
44                   input_shape,
45                   opset_version=11,
46                   show=False,
47                   output_file='tmp.onnx',
48                   verify=False):
49  ...

65      input_names=["input1"]
66      output_names=["output1"]

68      register_extra_symbolics(opset_version)
69      torch.onnx.export(
70          model,
71          one_img,
72          output_file,
73          export_params=True,
74          keep_initializers_as_inputs=True,
75          verbose=show,
76          opset_version=opset_version,
77          input_names=input_names,
78          output_names=output_names)
```

Defined here.
- Input name : *input1*
- Output name : *output1*

3.5: Prepare the Pre/Postprocessing Definition File

3. Open the *prepost_hrnet.yaml* with the editor.

```
$ vi $DRPAI/UserConfig/prepost_hrnet.yaml
```

4. Rewrite the input name to the model in the input data definition.

```
12 input_to_body:
13   -
14     name: "image2"
15     format: "RGB"
16     order: "HWC"
17     shape: [416, 416, 3]
18     type: "fp16"
```

Input name to model

```
12 input_to_body:
13   -
14     name: "input1"
15     format: "RGB"
16     order: "HWC"
17     shape: [416, 416, 3]
18     type: "fp16"
```

5. Rewrite the output name from the model in the output data definition.

```
23 output_from_body:
24   -
25     name: "grid"
26     shape: [13, 13, 125]
27     order: "HWC"
28     type: "fp16"
```

Output name from model

```
23 output_from_body:
24   -
25     name: "output1"
26     shape: [13, 13, 125]
27     order: "HWC"
28     type: "fp16"
```

3.5: Prepare the Pre/Postprocessing Definition File

6. Rewrite the input name to the model in preprocessing definition.

```
40 preprocess:
41   -
42     src       : ["camera_data"]
43
44     dest      : ["image2"]
```

Input name to model →

```
40 preprocess:
41   -
42     src       : ["camera_data"]
43
44     dest      : ["input1"]
```

7. Rewrite the output name to the model in the postprocessing definition.

```
74 postprocess:
75   -
76     src: ["grid"]
77
78     dest: ["post_out"]
```

Output name from model →

```
74 postprocess:
75   -
76     src: ["output1"]
77
78     dest: ["post_out"]
```

3.5: Prepare the Pre/Postprocessing Definition File

Next, change the input data format for the preprocessing from YUY2 to BGR.

8. Rewrite the input data format to the preprocessing in the input data definition.

```
4  input_to_pre:
5    -
6      name: "camera_data"
7      format: "YUY2"
8      order: "HWC"
9      shape: [480, 640, 2]
10     type: "uint8"
```

Input name
Format name
Number of channels

```
4  input_to_pre:
5    -
6      name: "bgr_data"
7      format: "BGR"
8      order: "HWC"
9      shape: [480, 640, 3]
10     type: "uint8"
```

9. Rewrite the input data to the preprocessing in the preprocessing definition.

```
40 preprocess:
41   -
42     src      : ["camera_data"]
```

Input name

```
40 preprocess:
41   -
42     src      : ["bgr_data"]
```

3.5: Prepare the Pre/Postprocessing Definition File

10. Comment out the *conv_yuv2rgb* operation (YUV to RGB conversion) in the preprocessing definition.

```
47  -
48      op: conv_yuv2rgb
49      param:
50        DOUT_RGB_FORMAT: 0 # "RGB"
```

```
47  # -
48  #     op: conv_yuv2rgb
49  #     param:
50  #       DOUT_RGB_FORMAT: 0 # "RGB"
```

11. Rewrite the parameter of *normalize* operation in the preprocessing definition.

Output format of normalize operation

```
64  -
65      op: normalize
66      param:
67        DOUT_RGB_ORDER: 0 # Output RGB order = Input RGB order
68        cof_add: [0.0, 0.0, 0.0]
69        cof_mul: [0.00392157, 0.00392157, 0.00392157]
```

```
64  -
65      op: normalize
66      param:
67        DOUT_RGB_ORDER: 1
68        cof_add: [0.0, 0.0, 0.0]
69        cof_mul: [0.00392157, 0.00392157, 0.00392157]
```

3.5: Prepare the Pre/Postprocessing Definition File

Next, set the parameters of normalize to the training value.

Since this guide uses the pre-trained model provided by MMPose, the training value of normalization can be confirmed in the Neural Network model structure file (*hrnet_w32_coco_256x192.py*).

Path: *$WORK/* mmpose/configs/body/2d_kpt_sview_rgb_img/topdown_heatmap/coco/hrnet_w32_coco_256x192.py

Quotes from hrnet_w32_coco_256x192.py

```
104  train_pipeline = [
105      dict(type='LoadImageFromFile'),
106      dict(type='TopDownRandomFlip', flip_prob=0.5),
107      dict(
     .
     .
     .
115      dict(
116          type='NormalizeTensor',
117          mean=[0.485, 0.456, 0.406],
118          std=[0.229, 0.224, 0.225]),
119      dict(type='TopDownGenerateTarget', sigma=2),
```

Use these values, ***mean=[0.485, 0.456, 0.406]*** and ***std=[0.229, 0.224, 0.225]*** to set the configuration of DRP-AI Translator.

3.5: Prepare the Pre/Postprocessing Definition File

Convert the Normalize parameter, *mean=[0.485, 0.456, 0.406]* and *std=[0.229, 0.224, 0.225]* to *add* and *mul*.

To compute, use the formulae explained in
"STEP-3.5: Prepare the Pre/Postprocessing Definition FIle" in the Get Started Document.

add = - (mean × range)

mul = 1 / (std × range)

To normalize the input data to the model between 0 and 1 as in PyTorch, use the maximum value of the input image dynamic range as "*range*", which is 255.

12. Compute *cof_add* and *cof_mul* in the *normalize* operation.

    Change the pre/postprocessing definition file based on the following result

    cof_add=[-123.675, -116.28, -103.53]
    cof_mul=[0.01712475, 0.017507, 0.01742919].

```
64  -
65      op: normalize
66      param:
67        DOUT_RGB_ORDER: 1
68        cof_add: [0.0, 0.0, 0.0]
69        cof_mul: [0.00392157, 0.00392157, 0.00392157]
```

```
64  -
65      op: normalize
66      param:
67        DOUT_RGB_ORDER: 1
68        cof_add: [-123.675, -116.28, -103.53]
69        cof_mul: [0.01712475, 0.017507, 0.01742919]
```

3.5: Prepare the Pre/Postprocessing Definition File

Next, Change the input/output size of the model based on HRNet.

Since this guide uses the pre-trained model provided by MMPose, the input/output size can be confirmed in the Neural Network model structure file (*hrnet_w32_coco_256x192.py*).

Path: *$WORK/* mmpose/configs/body/2d_kpt_sview_rgb_img/topdown_heatmap/coco/hrnet_w32_coco_256x192.py

Quotes from hrnet_w32_coco_256x192.py

```
87  data_cfg = dict(
88      image_size=[192, 256],
89      heatmap_size=[48, 64],
90      num_output_channels=channel_cfg['num_output_channels'],
```

```
29  channel_cfg = dict(
30      num_output_channels=17,
31      dataset_joints=17,
```

Input Size (HWC) = [256, 192, 3]

Output Size (HWC) = [64, 48, 17]

Use these values, **Input Size =[256, 192, 3]** and **Output Size =[64, 48, 17],** to set the configuration of DRP-AI Translator.

3.5: Prepare the Pre/Postprocessing Definition File

13. Rewrite the input size to the model in the input data definition.

```
12 input_to_body:
13   -
14     name: "input1"
15     format: "RGB"
16     order: "HWC"
17     shape: [416, 416, 3]
18     type: "fp16"
```

Input size to model

```
12 input_to_body:
13   -
14     name: "input1"
15     format: "RGB"
16     order: "HWC"
17     shape: [256, 192, 3]
18     type: "fp16"
```

14. Rewrite the parameters in resize operator in the preprocessing definition.

```
53       op: resize_hwc
54       param:
55         RESIZE_ALG: 1 # "Bilinear"
56         DATA_TYPE: 0  # "uint8"
57         shape_out: [416, 416]
58
```

Input size to model

```
53  op: resize_hwc
54       param:
55         RESIZE_ALG: 1 # "Bilinear"
56         DATA_TYPE: 0  # "uint8"
57         shape_out: [256, 192]
58
```

3.5: Prepare the Pre/Postprocessing Definition File

15. Rewrite the output size from the model in output data definition.

```
23 output_from_body:
24   -                    Output size from model
25     name: "grid"
26     shape: [13, 13, 125]
27     order: "HWC"
28     type: "fp16"
```

```
23 output_from_body:
24   -
25     name: "output1"
26     shape: [64, 48, 17]
27     order: "HWC"
28     type: "fp16"
```

16. Rewrite the output size from the postprocessing in output data definition definition.

```
30 output_from_post:
31   -
32     name: "post_out"
33     shape: [125, 13, 13]
34     order: "CHW"
35     type: "fp32"
```

Output size from postprocessing

```
30 output_from_post:
31   -
32     name: "post_out"
33     shape: [17, 64, 48]
34     order: "CHW"
35     type: "fp32"
```

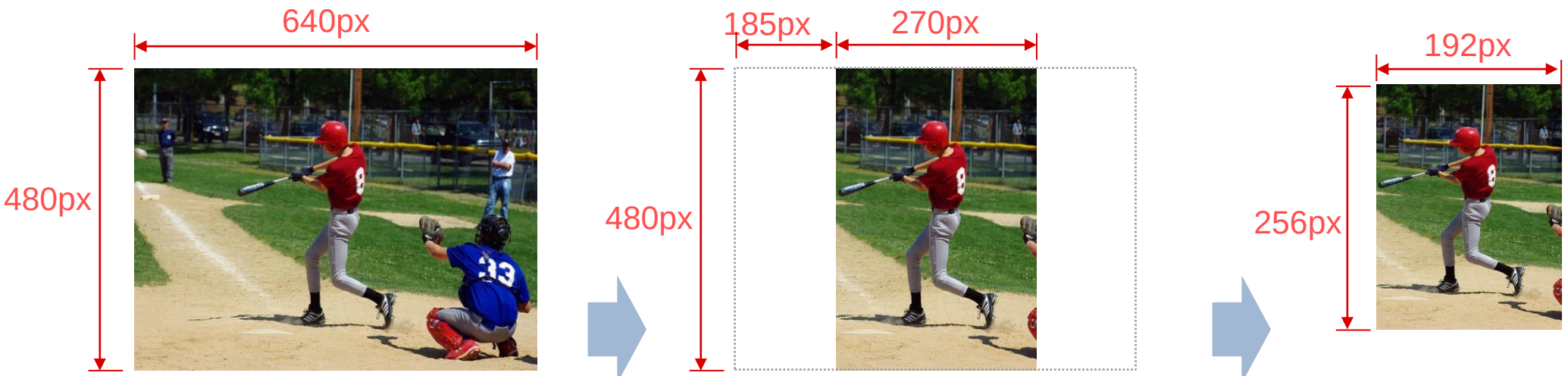
3.5: Prepare the Pre/Postprocessing Definition File

Last, Add the crop operator.

In this guide, the input image is size of width 640px and height 480px.
However, input data size to HRNet model must be width 192px and height 256px, which is vertical image.

Resizing the original image will change the aspect ratio significantly and change the recognition result.

In this document, we will crop the image and resize to fit the input data size to HRNet model.



3.5: Prepare the Pre/Postprocessing Definition File

17. Add the crop operator in preprocessing definition.

```
48 #       op: conv_yuv2rgb
49 #       param:
50 #         DOUT_RGB_FORMAT: 0 # "RGB"
51     -
52       op: resize_hwc
53
54
```

Add crop operator

```
48 #       op: conv_yuv2rgb
49 #       param:
50 #         DOUT_RGB_FORMAT: 0 # "RGB"
51     -
52       op: crop
53       param:
54         CROP_POS_X : 185
55         CROP_POS_Y : 0
56         DATA_TYPE : 0
57         DATA_FORMAT: 0 # 0 : HWC
58         shape_out: [480, 270] # [H, W]
59
60     -
61       op: resize_hwc
```

Major parameters are as follows.

param > CROP_POS_X : X coordinate where start cropping (Top-left)

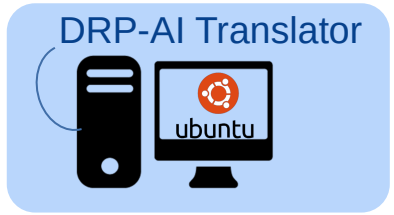
param > CROP_POS_Y : Y coordinate where start cropping (Top-left)

param > DATA_TYPE : Data type ("0" if uint8)

param > DATA_FORMAT : Data format("0" if HWC)

param > shape_out : Output data size from crop operator

For more details of crop operator, please refer to DRP-AI Translator User's Manual.

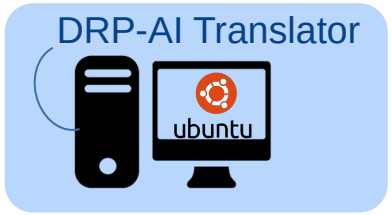


3.6: Translate the Model Using DRP-AI Translator

This section will explain how to run the DRP-AI Translator.

1. please confirm that there are following three files under *drp-ai_translator_release* directory.

- *drp-ai_translator_release*
  - *…*
  - *onnx*
    - *hrnet.onnx*
  - *UserConfig*
    - *addrmap_in_hrnet.yaml*
    - *prepost_hrnet.yaml*



3.6: Translate the Model Using DRP-AI Translator

2. Move to the DRP-AI Translator working directory.

```
$ cd $DRPAI
```

3. Translate the model with the following commands. (Please execute it under the *drp-ai_translator_release* directory.)
Blue is PREFIX (output directory) name. Any name is available.

For RZ/V2M, RZ/V2MA:

```
$ ./run_DRP-AI_translator_V2M.sh hrnet -onnx ./onnx/hrnet.onnx
```

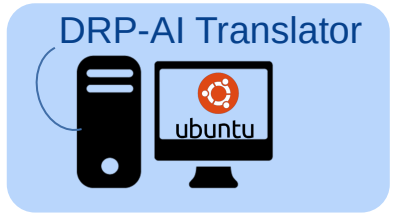
For RZ/V2L:

```
$ ./run_DRP-AI_translator_V2L.sh hrnet -onnx ./onnx/hrnet.onnx
```

If displayed as follows without any errors, translation is successful.

```
[Run DRP-AI Translator] Ver. 1.80
[Input file information]
   PREFIX               : hrnet
   ONNX Model           : ./onnx/hrnet.onnx
   Prepost file         : ./UserConfig/prepost_hrnet.yaml
   Address mapping file : ./UserConfig/addrmap_in_hrnet.yaml
      ...

-------------------------------------------
[Converter for DRP] Finish
```

<DRP-AI Translator environment>



3.7: Confirm the Translation Result

1. The translation result is stored in the output directory with PREFIX named at the time of translation.

```
$ ls -1 $DRPAI/output/hrnet/
```

If displayed as follows, the model is correctly translated.

```
aimac_desc.bin
drp_desc.bin
drp_lib_info.txt
drp_param.bin
drp_param.txt
drp_param_info.txt
hrnet.json
hrnet_addrmap_intm.txt
hrnet_addrmap_intm.yaml
hrnet_data_in_list.txt
hrnet_data_out_list.txt
hrnet_drpcfg.mem
hrnet_prepost_opt.yaml
hrnet_summary.xlsx
hrnet_tbl_addr_data.txt
hrnet_tbl_addr_data_in.txt
hrnet_tbl_addr_data_out.txt
hrnet_tbl_addr_drp_config.txt
hrnet_tbl_addr_merge.txt
hrnet_tbl_addr_weight.txt
hrnet_tbl_addr_work.txt
hrnet_weight.dat
```

Yellow files are DRP-AI Object files required for actual operation.

Green file is a summary file for estimating the processing time.

STEP-3 Summary

In STEP-3, DRP-AI Object files are generated from the ONNX model.

Please proceed to "STEP-4 Execute Inference with DRP-AI".

Program made in the Step

Output of previous step

STEP-1

Introduction

STEP-2

Convert to ONNX Format

ONNX conversion script

Pre-trained model

STEP-3

Translate to DRP-AI Object files

Configuration files

ONNX format model

STEP-4

Execute Inference with DRP-AI

AI execution environment

DRP-AI Object files

Execute Inference with DRP-AI

STEP-1
STEP-2
STEP-3
STEP-4

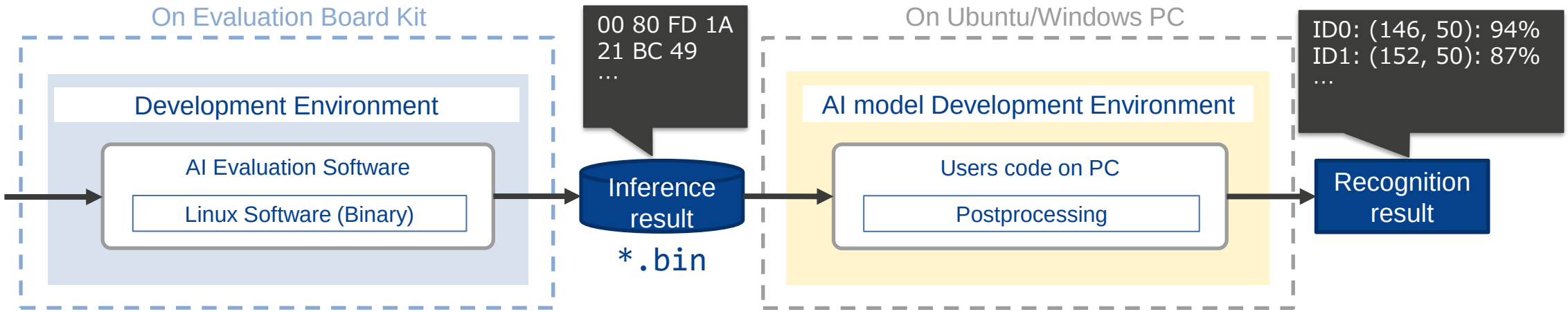
This section will explain the instruction with the following assumption

- Read "STEP-4 Execute Inference with DRP-AI" in the Get Started Document.

The DRP-AI Object files for HRNet created in STEP-3 can be executed by AI Evaluation Software.

AI Evaluation Software will generate a binary file that contains the DRP-AI inference result, which is not the recognition result.

To obtain recognition result, we need to apply the CPU post-processing specialized for HRNet.



Note: To see how to use AI Evaluation Software, please refer to AI Evaluation Software Guide.

Execute Inference with DRP-AI

This document provides the post-processing script for MMPose HRNet, which runs on Linux PC.

Path: *$WORK/mmpose/hrnet/postprocess_hrnet.py*

Details of the script are as follow.

Notes

- ✓ Assumed to have run following post-processing on DRP-AI
  - transpose
  - castFP16toFP32
- ✓ Install the necessary packages listed in Confirmed Operational Environment below appropriately.
- ✓ To see the details of algorithm, refer to HRNet paper (https://arxiv.org/pdf/1902.09212.pdf).
- ✓ The script uses the AI Evaluation Software output of $WORK/mmpose/hrnet/sample.bmp image.
  - ✓ The script draws the estimated skeleton on the input image. Please specify the name of input image used when executing the AI Evaluation Software.

Confirmed Operational Environment

```
Ubuntu 20.04 LTS        Python        == 3.8.10
                        pip           == 22.2.2
                        torch         == 1.12.1+cpu
                        numpy         == 1.23.1
                        opencv-python == 4.6.0.66
                        mmcv          == 1.6.1
```

DRP-AI Inference Result Binary Data

Details of the DRP-AI inference result binary file are as follow.

- Number of data : 52224 (Depends on the model output size. e.g., (1x17x64x48))
- Data width : 4byte (Because of castFP16toFP32, width is FP32=4byte)
- Byte order : Little endian

Execute Inference with DRP-AI

From *postprocess_hrnet.py*

```
...
if __name__ == '__main__':
    output_shape = [1, 17, 64, 48] # [N, C, H, W]
    input_size_x = 192 # Width of model input
    input_size_y = 256 # Height of model input

    # Drawing parameters
    kpt_score_thr=0.3
    thickness=1
    radius=4

    # dataset: 'TopDownCocoDataset'
    palette = np.array([[255, 128, 0], [255, 153, 51], [255, 178, 102],
    ...
    # Label from COCO dataset "https://arxiv.org/abs/1405.0312"
    label = {
    ...
                                ※sample.bmp.bin is the result of AI Evaluation Software with sample input image ($WORK/mmpose/hrnet/sample.bmp)
    # Load DRP-AI output binary
    result_bin = open("sample.bmp.bin", 'rb')
    data = np.zeros(output_shape, dtype=float)
    for c in range(output_shape[1]):
        for h in range(output_shape[2]):
            for w in range(output_shape[3]):
                a = struct.unpack('<f', result_bin.read(4))
                data[0, c, h, w] = a[0]

    # Postprocess
    ...
    # Image processing
    img = mmcv.imread("sample.bmp")  ※sample.bmp is sample input image($WORK/mmpose/hrnet/sample.bmp)
    ...
    # Print out result
    for i in range(len(all_preds[0])):
        print('ID {:2} {:14}: ({:3.0f}, {:3.0f}): {:5.1%}'.format(i, label[i], all_preds[0,i,0],all_preds[0,i,1],all_preds[0,i,2]))

    # Draw skeleton
    imshow_keypoints(img, all_preds, skeleton, kpt_score_thr,
    ...
    imwrite(img, "result.jpg")
```

Input/Output size of model

Drawing Parameters

Drawing parameters for COCO Dataset

Label for key point (joint)

Load inference result binary file

Read FP32 data for [64x48x17]
Specify little endian

Load input image for drawing

Print the postprocessing result on console

Draw skeleton

Save skeleton image

STEP-1
STEP-2
STEP-3
STEP-4

Execute Inference with DRP-AI

Running the *postprocess_hrnet.py* with sample input image *($WORK/mmpose/hrnet/sample.bmp)* will generate following results.

Terminal Log

```
ID  0 nose          : ( 82,  66): 92.8%
ID  1 left_eye      : ( 82,  64): 94.8%
ID  2 right_eye     : ( 82,  62): 85.4%
ID  3 left_ear      : ( 92,  64): 92.1%
ID  4 right_ear     : (100,  60): 72.1%
ID  5 left_shoulder : ( 96,  84): 85.0%
ID  6 right_shoulder: (120,  68): 87.4%
ID  7 left_elbow    : ( 76, 100): 91.0%
ID  8 right_elbow   : ( 88,  80): 71.7%
ID  9 left_wrist    : ( 56,  90): 91.9%
ID 10 right_wrist   : ( 64,  84): 81.1%
ID 11 left_hip      : (102, 128): 76.9%
ID 12 right_hip     : (112, 124): 63.3%
ID 13 left_knee     : ( 98, 176): 92.0%
ID 14 right_knee    : ( 66, 158): 88.1%
ID 15 left_ankle    : (146, 194): 87.7%
ID 16 right_ankle   : ( 72, 204): 87.4%
```

(X, Y) Score

Input image(sample.bmp)

Output image (result.jpg)

STEP-4 Summary

STEP-4 explained how to execute the AI inference using DRP-AI.

In the DRP-AI Sample Application, we provide the sample application that runs inference through CPU post-processing on the board with MMPose HRNet model, which is explained in this document.

To see how to use the application, please refer to the DPR-AI Sample Application Note.

Conclusion

Throughout STEP-1 to STEP-4, we have explained how to run the HRNet model provided by MMPose on the RZ/V2x.

If you have any questions, please contact us.

Thank you for reading to the end.

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Version History

Date	Version	Chapter	Contents
Sep. 29, 2022	7.20	-	Issued. (Unified AI Implementation Guide for RZ/V2L, RZ/V2M, RZ/V2MA)