DEEPX
DX-M1 & DX-M1M
Quick User Manual
for Raspberry Pi 5

Revision: v1.3

Document History

Version	Date	Description	Author
V1.3	2026.11.06	- Update DX-M1 Driver and Runtime Installation guide for SDK 2.5.0 release - Add Raspberry Pi Camera Module 3 (Wide) connection and camera verification steps - Add camera input demos for dx_app and dx_stream - Update dx_app installation to use a Python virtual environment - Replace all screen captures	Brad Kim
V1.2	2026.05.15	- Update M1 Driver and Runtime Installation guide for SDK 2.3.0 release	JC Yoo
V1.1	2026.04.08	- Fix hyphen copying issues in source code and improved readability and the typo - Add Chapter 3.2.2 and Appendix for firmware update - Add “./install.sh” in dx_app and dx_stream	JC Yoo
V1.0	2026.02.24	Full-Scale Revision	JC Yoo
V0.1	2025.05.07	Initial Release	EM Kim

Copyright ⓒ 2026 by DEEPX. All rights reserved.

TERMS OF USE

DEEPX Company Limited (DEEPX) reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to DEEPX's terms and conditions of sale supplied at the time of order acknowledgment.

DEEPX assumes no liability for application assistance or customer product designs. Customers are responsible for their products and applications using DEEPX components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

DEEPX does not warrant or represent that any license, either express or implied, is granted under any DEEPX patent right, copyright, mask work right, or other DEEPX intellectual property right relating to any combination, machine, or process in which DEEPX products or services are used. Information published by DEEPX regarding third-party products or services does not imply any license, warranty, or endorsement by DEEPX. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from DEEPX under the patents or other intellectual property of DEEPX.

Reproduction of DEEPX information in DEEPX data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alterations is an unfair and deceptive business practice. DEEPX is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

DEEPX products are not authorized for use in safety-critical applications (such as life support) where a failure of the DEEPX product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of DEEPX products in such safety-critical applications, notwithstanding any application-related information or support that may be provided by DEEPX. Further, Buyers agree to indemnify DEEPX and its representatives from any claims or damages arising from unauthorized use of DEEPX products in safety-critical applications.

DEEPX products are neither designed nor intended for use in military/aerospace applications or environments unless the DEEPX products are specifically designated by DEEPX as military-grade or "enhanced plastic."

DEEPX products are neither designed nor intended for use in automotive applications or environments unless the specific DEEPX products are designated by DEEPX as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, DEEPX will not be responsible for any failure to meet such requirements.

ⓒ DEEPX Co., Ltd.

All rights reserved. No part of this document may be reproduced in any form without written permission from DEEPX Co., Ltd. DEEPX Co., Ltd. reserves the right to change in its products or product specifications to improve function or design at any time, without notice.

Address : 3F, 20, Pangyoyeok-ro 241beon-gil, Bundang-gu, Seongnam-si, Gyeonggi-do, Republic of Korea

Tel : +82-31-603-9877

URL : https://www.deepx.ai

Email : tech_support@deepx.ai

Contents

1. Introduction 5

2. System Overview 6

2.1. Hardware Architecture: DX-M1 M.2 6

2.2. Hardware Installation and I/O Setup 7

3. Getting Started 9

3.1. System Prerequisites 9

3.2. Software Setup and Demo Execution 10

3.2.1. Install DEEPX DX-M1 Driver and Runtime 10

3.2.2. [Optional] Firmware Update 12

3.2.3. Execution of Sample Applications 13

3.2.4. System Monitoring 17

3.2.5. PCIe Gen3 Configuration 18

Appendix. Troubleshooting 19

Q1. Firmware Version Mismatch Error Message 19

Copyright ⓒ 2026 by DEEPX. All rights reserved.

1. Introduction

The **DX-M1** (& **DX-M1M**) is an entry-to-mid level edge NPU designed for high-performance AI acceleration. This manual provides technical guidance for integrating the **DEEPX DX-M1** (& **DX-M1M**) **Accelerator Card** with the **Raspberry Pi 5** via PCIe M.2. It covers hardware architecture, installation with thermal management, and the software setup required for AI inference, including sample applications and real-time monitoring via `dxtop`.

Copyright ⓒ 2026 by DEEPX. All rights reserved.

2. System Overview

This chapter provides a technical overview of the **DEEPX DX-M1** accelerator and its integration environment.

2.1. Hardware Architecture: DX-M1 M.2

The system utilizes a high-performance heterogeneous architecture specifically engineered to support demanding edge AI workloads.

DX-M1 M.2 Accelerator Card Specifications

The DEEPX DX-M1 is a high-efficiency AI inference accelerator designed for seamless integration into edge computing environments through its optimized internal architecture.



Figure 1. DX-M1 M.2 Architecture

Table. DX-M1 M.2 Technical Specifications

Features	Details
AI Performance	25 TOPS (INT8)
Host Interface	PCIe Gen3 x4 (Supports Gen 1/2/3 & x1/x2/x4)
Memory	4GB LPDDR5 (5600 MT/s)
Power Consumption	1W (min) ~ 5W (max)
Form Factor	M.2 2280 (M Key), 22 x 80 mm
OS Support	Windows 11/10 Debian-based Linux (Ubuntu 24.04/22.04/20.04 LTS, Raspberry Pi OS) Yocto Project
AI Frameworks	Ultralytics, PyTorch, TensorFlow, ONNX, Keras
System Support	x86 and ARM-based Architectures

Copyright ⓒ 2026 by DEEPX. All rights reserved.

2.2. Hardware Installation and I/O Setup

This section outlines the physical integration of the DEEPX DX-M1 accelerator. Follow these steps to ensure the host system and hardware components are properly configured for a stable edge AI environment.

Step-by-Step Connection Guide

Step 1. Raspberry Pi 5 Initial Setup

Complete the basic OS and power configuration by referring to the official documentation:

- **Getting started with your Raspberry Pi**
  (https://www.raspberrypi.com/documentation/computers/getting-started.html)

Step 2. Connecting the DX-M1 M.2 Module

Once the host is prepared, install the **DX-M1 M.2 NPU module** via the PCIe M.2 HAT as shown in **Figure 2**.

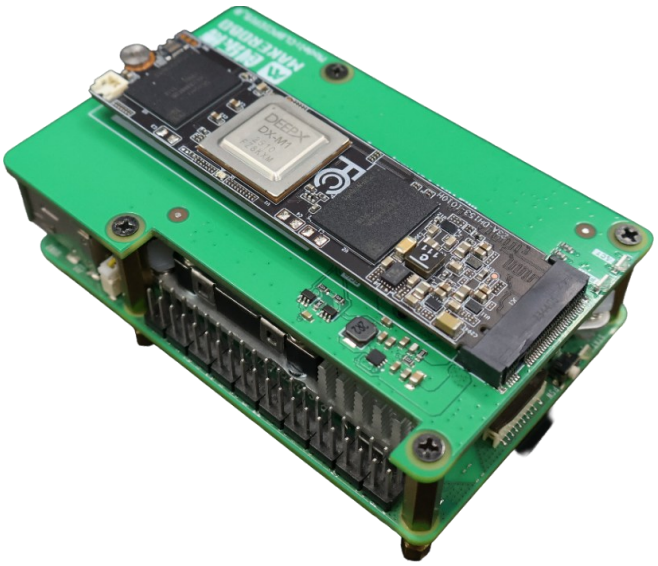


Figure 2. DEEPX DX-M1 AI Accelerator for Raspberry Pi 5

Copyright ⓒ 2026 by DEEPX. All rights reserved.

Step 3. Connecting the Raspberry Pi Camera Module 3 (Wide)

To run the camera input demos, connect the **Raspberry Pi Camera Module 3 (Wide)** (**Figure 3**) to the CAM/DISP 0 or CAM/DISP 1 connector on the Raspberry Pi 5.



Figure 3. Raspberry Pi Camera Module 3 (Wide)

- Power off the Raspberry Pi 5 and disconnect the power supply.
- Gently lift the latch of the CAM/DISP 0 or CAM/DISP 1 connector.
- Insert the camera cable fully and straight into the connector.
- Press the latch down to secure the cable, as shown in **Figure 4**.

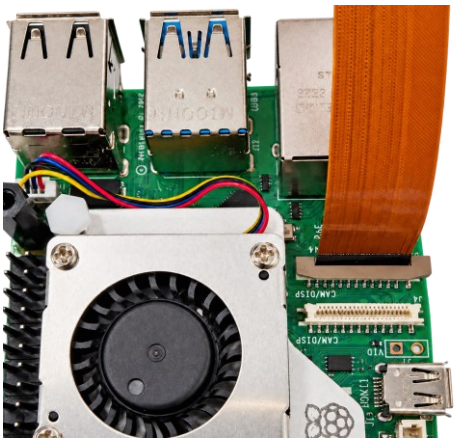


Figure 4. Camera Cable Connected to the Raspberry Pi 5 Camera Connector

NOTE. The Raspberry Pi 5 uses mini 22-pin camera connectors, while the cable included with the Camera Module 3 is a standard 15-pin cable. A **Standard-to-Mini camera cable is required** to connect the camera to the Raspberry Pi 5.

Copyright ⓒ 2026 by DEEPX. All rights reserved.

3. Getting Started

This chapter provides a concise guide to configuring the **DEEPX DX-M1** development environment. It covers the essential steps from verifying system requirements to executing your first AI inference benchmarks.

3.1. System Prerequisites

Before proceeding with the driver installation, ensure the host system is properly configured by following these environment preparation steps.

Environment Preparation

Step 1. Install Raspberry Pi OS

- Download and install the OS using the **Raspberry Pi Imager**.
- **Link:** https://www.raspberrypi.com/software/

Step 2. Connect to the Internet

- Verify that the Raspberry Pi has an active **Internet connection**.
- A stable connection is required to access external repositories and download necessary dependencies during the setup process.

Step 3. Connect and Verify the Camera

- Connect the **Raspberry Pi Camera Module 3 (Wide)** as described in **Section 2.2, Step 3**.
- Run the following command to verify that the camera is recognized.

```
$ rpicam-hello --list-cameras
```

If the camera is recognized correctly, `imx708_wide` is listed in the output.

Copyright ⓒ 2026 by DEEPX. All rights reserved.

3.2. Software Setup and Demo Execution

This section provides a brief guide to installing the necessary drivers and executing AI inference benchmarks using the DEEPX DX-M1 accelerator.

3.2.1. Install DEEPX DX-M1 Driver and Runtime

Follow these steps to download and install the **DEEPX Runtime (DX-RT) library**, known as `libdxrt`, along with the necessary driver modules.

Step 1. Download the Debian Packages

Execute the following commands to download the latest Debian packages.

```
# Download the Debian packages to the Downloads folder
$ wget -P ~/Downloads https://github.com/DEEPX-AI/dx_rt/raw/refs/heads/main/release/3.5.0/libdxrt-bin_3.5.0_arm64.deb

$ wget -P ~/Downloads https://github.com/DEEPX-AI/dx_rt_npu_linux_driver/raw/refs/heads/main/release/2.7.0/dxrt-driver-dkms_2.7.0-2_all.deb
```

Step 2. Installation of DXRT and Driver

Install the DEEPX Runtime (DX-RT) library and the NPU driver.

```
$ sudo apt install -y ~/Downloads/dxrt-driver-dkms_2.7.0-2_all.deb
$ sudo apt install -y ~/Downloads/libdxrt-bin_3.5.0_arm64.deb
```

Copyright ⓒ 2026 by DEEPX. All rights reserved.

```
Unpacking libdxrt-bin (3.5.0) ...
Setting up libdxrt-bin (3.5.0) ...
Created symlink '/etc/systemd/system/multi-user.target.wants/dxrt.service' → '/etc/systemd/system/dxrt.service'.
[libdxrt-bin] dxrt.service installed and started.
[libdxrt-bin] installed.
  Binaries : /usr/local/bin
  Libraries: /usr/local/lib
  Headers  : /usr/local/include

[libdxrt-bin] === dx_engine Python wheel: manual install required ===
  The dx_engine wheel is staged but NOT installed. Pick the
  wheel whose ABI tag (cp310, cp311, cp312, ...) matches
  your Python interpreter and install it yourself.

  Staged wheels in /usr/share/libdxrt-bin/python:
    - dx_engine-3.5.0-cp310-cp310-manylinux2014_aarch64.manylinux_2_17_aarch64.whl
    - dx_engine-3.5.0-cp311-cp311-manylinux2014_aarch64.manylinux_2_17_aarch64.whl
    - dx_engine-3.5.0-cp312-cp312-manylinux2014_aarch64.manylinux_2_17_aarch64.whl
    - dx_engine-3.5.0-cp313-cp313-manylinux2014_aarch64.manylinux_2_17_aarch64.whl
    - dx_engine-3.5.0-cp314-cp314-manylinux2014_aarch64.manylinux_2_17_aarch64.whl
    - dx_engine-3.5.0-cp38-cp38-manylinux2014_aarch64.manylinux_2_17_aarch64.whl
    - dx_engine-3.5.0-cp39-cp39-manylinux2014_aarch64.manylinux_2_17_aarch64.whl

  System python3 (Ubuntu 23.04+ requires --break-system-packages):
    python3 -m pip install /usr/share/libdxrt-bin/python/dx_engine-*-cpXY-cpXY-*.whl

  Virtualenv / conda / uv (activate first, then match its Python):
    source /path/to/venv/bin/activate
    PYTAG=cp$(python -c 'import sys;print(f"{sys.version_info[0]}{sys.version_info[1]}")')
    pip install /usr/share/libdxrt-bin/python/dx_engine-*-${PYTAG}-${PYTAG}-*.whl
  ============================================================
Processing triggers for libc-bin (2.41-12+rpt1+deb13u2) ...
Notice: Download is performed unsandboxed as root as file '/home/dxuser/Downloads/libdxrt-bin_3.5.0_arm64.deb' couldn't
be accessed by user '_apt'. - pkgAcquire::Run (13: Permission denied)
dxuser@raspberrypi:~ $
```

Figure 5. DEEPX Runtime Library (libdxrt) Installation Progress

Step 3. Hardware Status Verification

Confirm that the DEEPX DX-M1 module is correctly interfaced and recognized by the system.

```
$ dxcli -s
```

```
dxuser@raspberrypi:~ $ dxcli -s
DXRT v3.5.0 (build: 5.502926e)
============================================================
 * Device 0: M1, Accelerator type
--------------------   Version   --------------------
 * RT Driver version   : v2.7.0
 * PCIe Driver version : v2.7.0
------------------------------------------------------------
 * FW version          : v2.7.6 (build: 0.1a2b3c4)
-------------------- Device Info ---------------------
 * Memory : LPDDR5x 6000 Mbps, 3.92GiB
 * Board  : M.2, Rev 1.0
 * Chip Offset : 0
 * PCIe   : Gen3 X1 [01:00:00]

NPU 0: voltage 0 mV, clock 1000 MHz, temperature 30'C
NPU 1: voltage 0 mV, clock 1000 MHz, temperature 30'C
NPU 2: voltage 0 mV, clock 1000 MHz, temperature 30'C
============================================================
dxuser@raspberrypi:~ $
```

Figure 6. Hardware Verification using dxcli -s Command

Copyright ⓒ 2026 by DEEPX. All rights reserved.

3.2.2. [Optional] Firmware Update

To ensure full compatibility between the `libdxrt` library and the hardware, the device firmware **must** meet the minimum version requirements.

Prerequisites for Update

Perform a firmware update if any of the following conditions occur.

- **Version Mismatch:** The current firmware version is lower than the minimum requirement.
- **Execution Error:** A `[dxrt-exception] Invalid operation` error occurs during model execution.

Firmware Download

The latest firmware binaries and guides are available at the official DEEPX GitHub repository.

- **URL:** https://github.com/DEEPX-AI/dx_fw

Quick Update Procedure

After downloading the firmware, execute the following commands.

```
# 1. Stop service
$ sudo systemctl stop dxrt.service


# 2. Update firmware
$ dxcli -u <path_to_fw_bin>


# 3. Restart service
$ sudo systemctl start dxrt.service
```

CAUTION. **Do not power off** the device during the update to prevent permanent hardware damage.

Copyright ⓒ 2026 by DEEPX. All rights reserved.

3.2.3. Execution of Sample Applications

A. AI Inference Demo (dx_app)

The dx_app demonstrates real-time AI inference capabilities. The execution script automatically handles the acquisition of sample video assets and pre-compiled models.

```
$ mkdir ~/sample
$ cd ~/sample
$ git clone --recurse-submodules https://github.com/DEEPX-AI/dx_app.git
$ cd dx_app
$ ./install.sh --all --venv_path ./venv
$ source ./venv/bin/activate
$ ./run_demo.sh
```

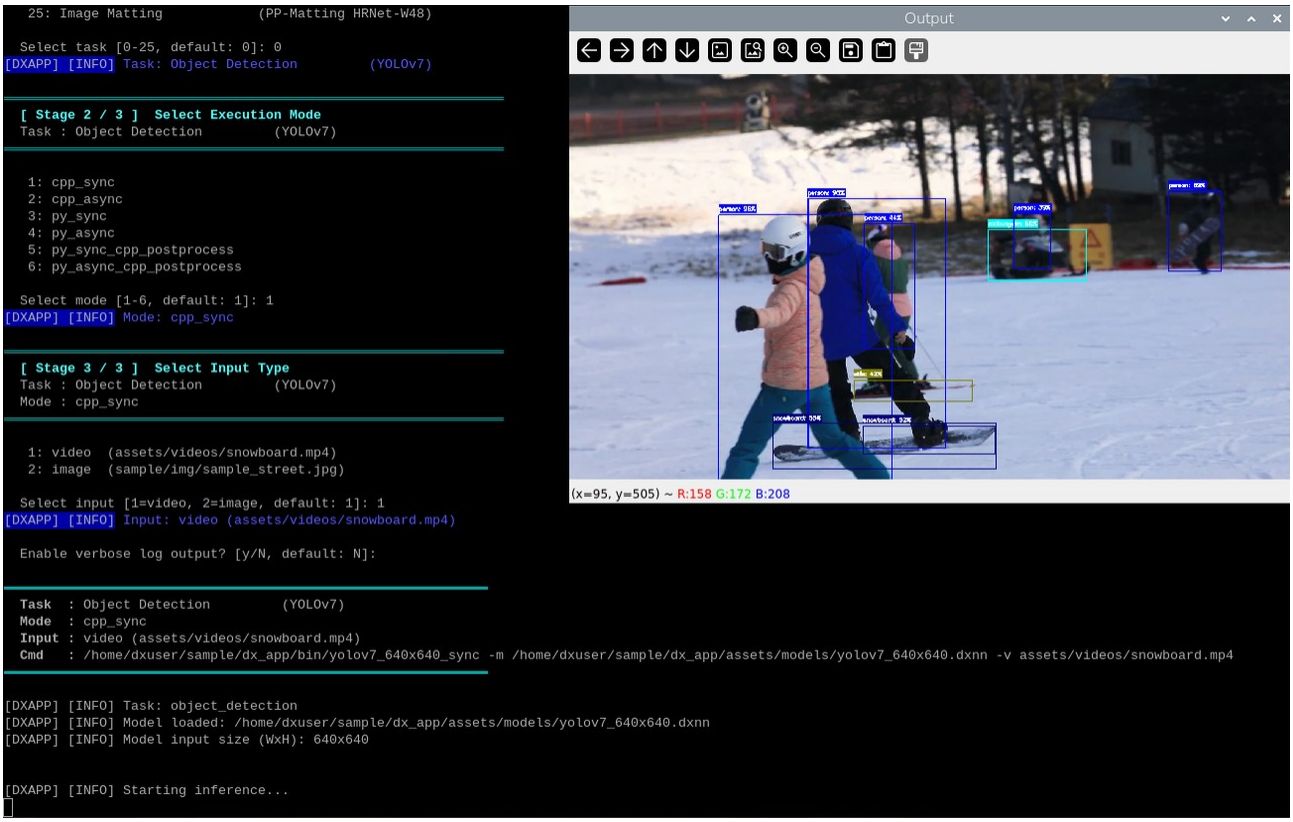


Figure 7. dx_app Video Demo: Demo Menu Selection (terminal) and Real-time Object Detection Result (result window)

Copyright ⓒ 2026 by DEEPX. All rights reserved.

NOTE. The default execution mode (cpp_sync) runs without additional packages. To use the Python execution modes (py_sync, py_async, py_sync_cpp_postprocess, py_async_cpp_postprocess), install the dx_engine Python package in the activated virtual environment. The wheel that matches your Python version is selected automatically.

```
$ pip install dx_engine --find-links /usr/share/libdxrt-bin/python
```

Camera Input Demo (dx_app)

The run_demo.sh script supports video and image inputs only. To run real-time inference on a camera input, execute an example directly with the -c <camera index> option.

```
$ cd ~/sample/dx_app
$ source ./venv/bin/activate
$ ./bin/yolo11-n_640x640_async -c 0
```

The example automatically detects the connected camera, either a USB webcam or the Raspberry Pi camera, and runs with it. For the Raspberry Pi camera, use the camera index shown by rpicam-hello --list-cameras (for example, 0).

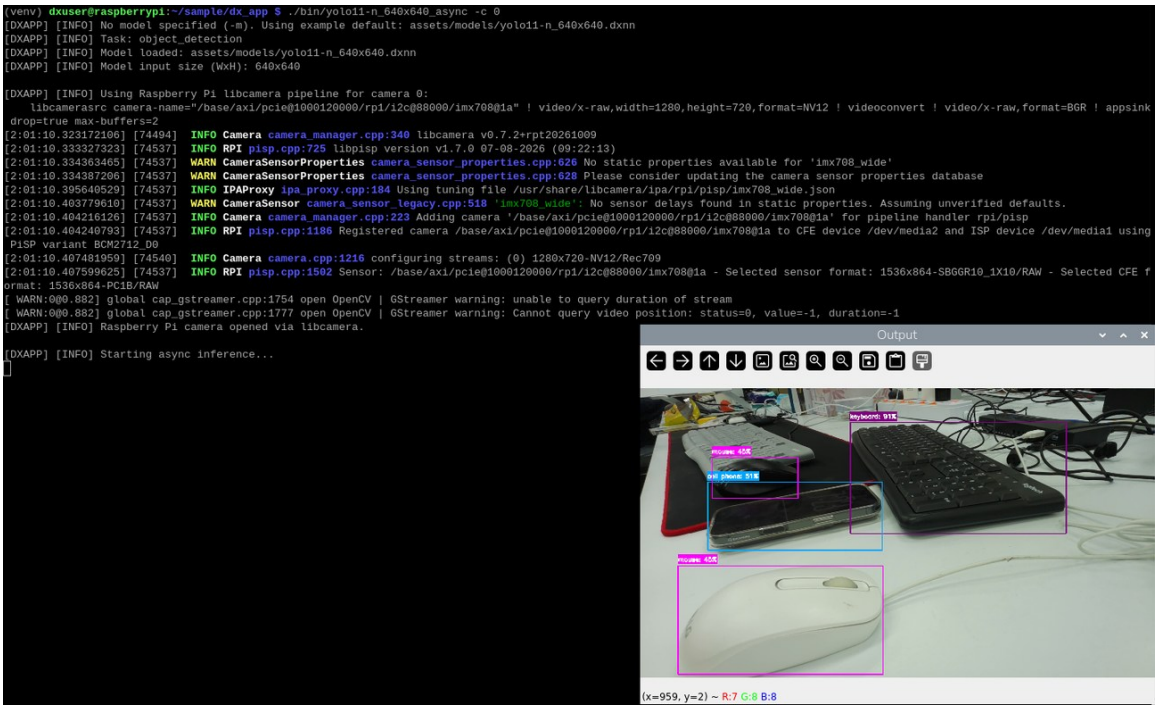


Figure 8. dx_app Camera Input Demo: Camera Inference Command (terminal) and Real-time Object Detection Result (result window)

NOTE. If a USB webcam and the Raspberry Pi camera are connected at the same time, -c 0 opens the USB webcam. To use the Raspberry Pi camera, disconnect the USB webcam.

Copyright ⓒ 2026 by DEEPX. All rights reserved.

B. GStreamer Plugin Demo (dx_stream)

The dx_stream sample is optimized for high-performance video streaming pipelines utilizing the GStreamer framework.

```
$ cd ~/sample
$ git clone --recurse-submodules https://github.com/DEEPX-AI/dx_stream.git
$ cd dx_stream
$ ./install.sh
$ ./build.sh
$ ./run_demo.sh
```



Figure 9. dx_stream GStreamer Pipeline: Demo Menu Selection (terminal) and Multi-Object Detection Result (result window)

Camera Input Demo (dx_stream)

When the Raspberry Pi Camera Module 3 (Wide) is connected, run_demo.sh lists additional **[Raspberry Pi Camera]** demos. Enter one of the following keys at the demo menu to run inference on the camera input.

- c: Object Detection (YOLO26n)
- p: Pose Estimation (YOLO26n_Pose)
- s: Instance Segmentation (YOLO26n_Seg)
- d: Depth Estimation (YOLO26n_Depth)

```
$ cd ~/sample/dx_stream
$ ./run_demo.sh
```

Copyright ⓒ 2026 by DEEPX. All rights reserved.

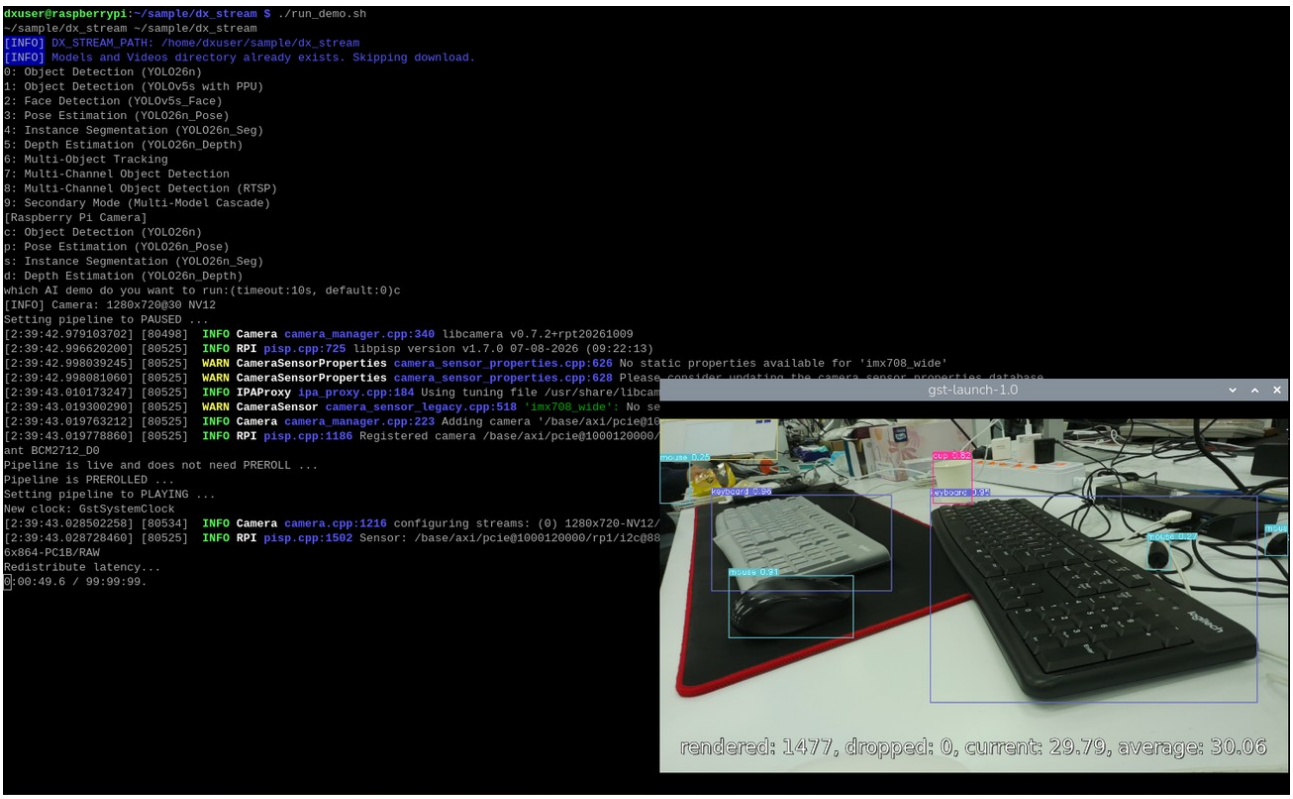


Figure 10. dx_stream Camera Input Demo: Demo Menu Selection (terminal) and Real-time Object Detection Result (result window)

NOTE. The demo menu waits for 10 seconds. If no selection is made within this time, demo 0 runs by default.

Copyright ⓒ 2026 by DEEPX. All rights reserved.

3.2.4. System Monitoring

NPU Utilization (dxtop)

The dxtop utility provides a real-time CLI(Command Line Interface) to monitor NPU utilization, temperature, and operational status.

```
$ dxtop
```

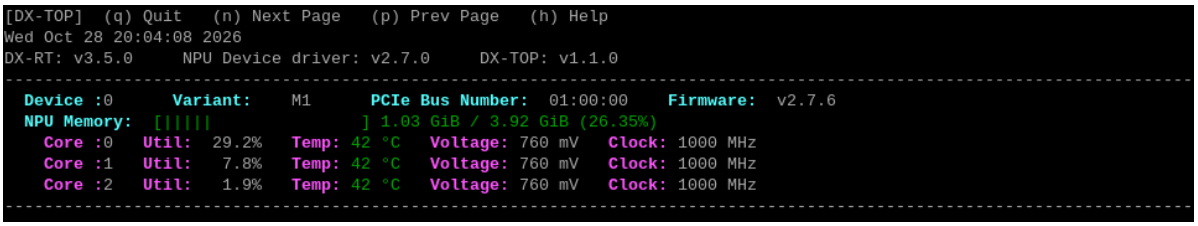


Figure 11. Real-time NPU Resource Monitoring via dxtop

Copyright ⓒ 2026 by DEEPX. All rights reserved.

3.2.5. PCIe Gen3 Configuration

To maximize the throughput of the DX-M1 accelerator, it is recommended to manually force the interface to **PCIe Gen3**.

Manual Configuration via `config.txt`

This method involves editing the system configuration file to enforce Gen3 speeds manually.

Step 1. Open the configuration file

```
$ sudo nano /boot/firmware/config.txt
```

NOTE. In older versions of the OS, the path may be `/boot/config.txt`.

Step 2. Add or modify the PCIe parameters

```
# Enable the PCIe external connector (M.2 HAT)
dtparam=pciex1


# Force PCIe Gen3 speed (Required for 25 TOPS performance)
dtparam=pciex1_gen=3
```

Step 3. Save and Exit

Press **Ctrl + O**, then **Enter** to save the changes, and press **Ctrl + X** to exit the editor.

Step 4. Reboot the system

```
$ sudo reboot
```

Verification of PCIe Link Speed

After rebooting, you can verify if the PCIe Gen3 configuration has been applied correctly by checking the Link Status.

```
$ sudo lspci -vv | grep -i LnkSta:
```

- If the output shows **Speed 8GT/s**, the system is successfully operating at **PCIe Gen3** speeds.
- If the output shows **Speed 5GT/s**, it is operating at **PCIe Gen2**.

NOTE. To achieve the maximum AI performance of 25 TOPS, the link speed **must** be confirmed as **8GT/s**.

Copyright ⓒ 2026 by DEEPX. All rights reserved.

Appendix. Troubleshooting

Q1. Firmware Version Mismatch Error Message

Issue Description

When executing the AI demo application, the program terminates with a red `[dxrt-exception]` error message. This occurs when the current hardware firmware version is incompatible with the runtime library (`libdxrt`) requirements.

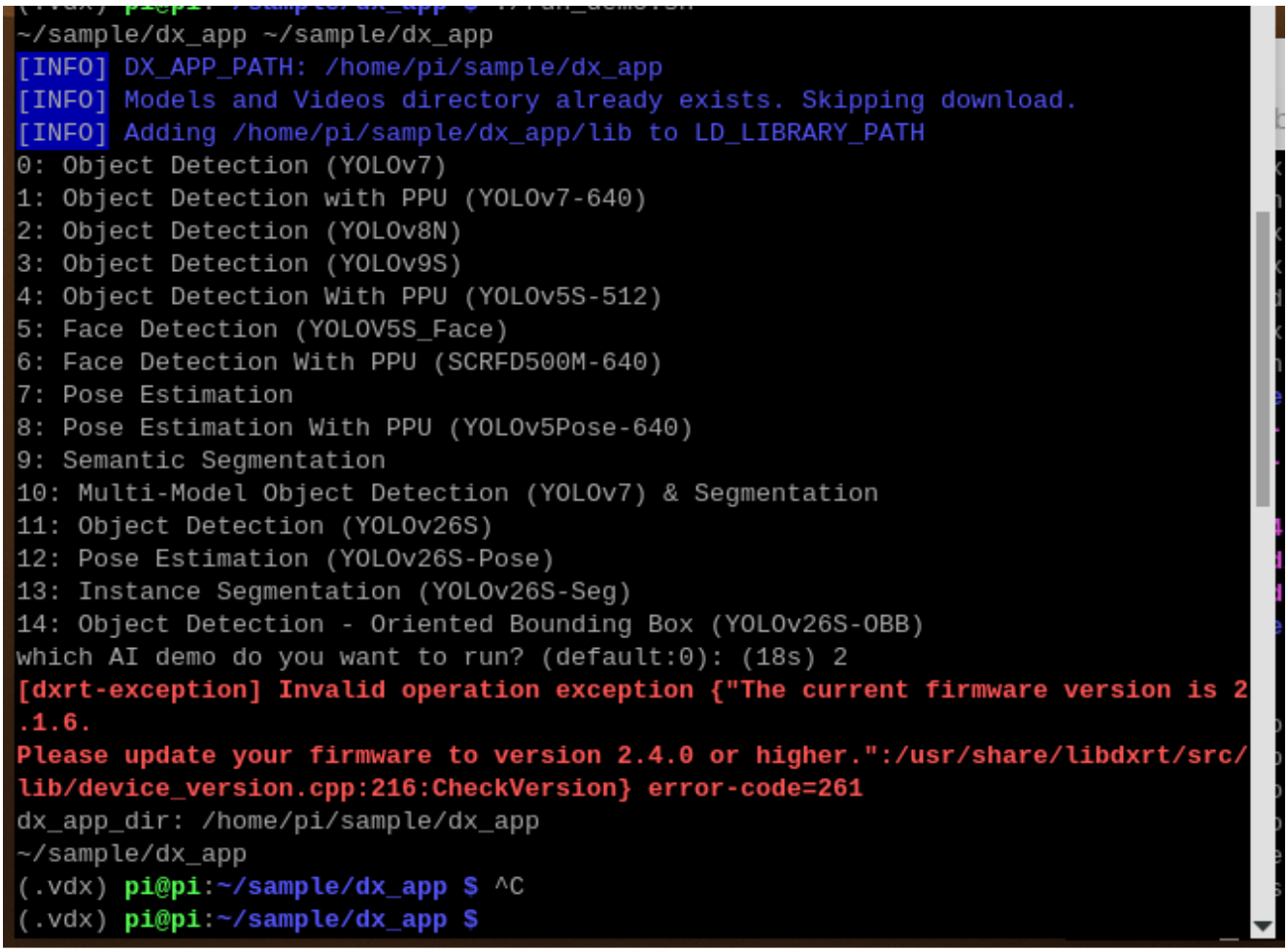


Figure 12. Firmware Version Mismatch Error in Demo Execution

Cause

- **Version Conflict:** The system has detected that the installed firmware is lower than the minimum required version needed.

Solution

- To resolve this, you must perform a manual firmware upgrade to ensure the hardware can communicate correctly with the latest SDK features. Refer to **Section 3.2.2. [Optional] Firmware Update.**

Copyright ⓒ 2026 by DEEPX. All rights reserved.