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About Freenove

Freenove provides open source electronic products and services worldwide.

Freenove is committed to assist customers in their education of robotics, programming and electronic circuits so that they may transform their creative ideas into prototypes and new and innovative products. To this end, our services include but are not limited to:

- Educational and Entertaining Project Kits for Robots, Smart Cars and Drones
- Educational Kits to Learn Robotic Software Systems for Arduino, Raspberry Pi, micro: bit and Raspberry Pi Pico W.
- Electronic Component Assortments, Electronic Modules and Specialized Tools
- **Product Development and Customization Services**

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Contents

Raspberry Pi AI Kit

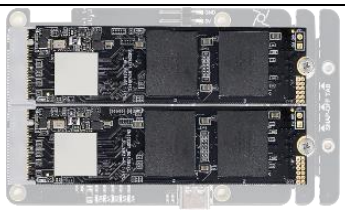
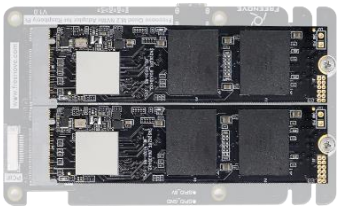
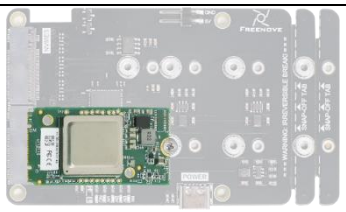
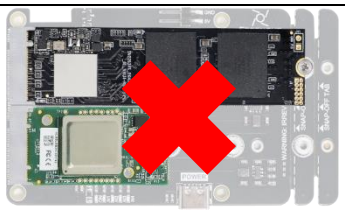
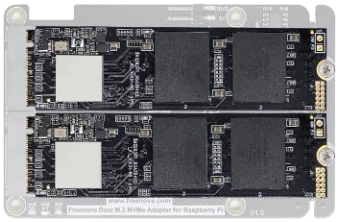
In this chapter, we will add a Hailo AI acceleration module provide Neural Processing Unit (NPU) support for the Raspberry Pi 5 with, enabling it with artificial intelligence neural network acceleration capabilities. You can plug the Hailo module to any of the NVMe interface. (Note: This project requires a Raspberry Pi camera.)

Cautions

1. The 4-Slot SSD Adapter Board does not support using the AI kit together with the NVMe.
2. The 2-Slot SSD Adapter Board allows using the AI kit and the NVMe simultaneously.

Why is that?

The 4-Slot SSD Adapter Board creates additional downstream virtual bridge devices, which consumes more of the Raspberry Pi's PCIe resources—especially legacy INTx interrupt routing resources. As a result, no remaining resources are available for the AI Kit, making it impossible to run both NVMe SSDs and the AI Kit simultaneously.

	Only SSD	Only AI Kit	SSD & AI Kit
4-Slot SSD Adapter Board	 Top  Bottom		
2-Slot SSD Adapter Board			

About Hailo AI Acceleration Module

The AI module is a 13 tera-operations per second (TOPS) neural network inference accelerator built around the Hailo-8L chip. The module uses the M.2 2242 form factor, to which it connects through an M key edge connector. It provides an accessible, cost-effective, and power- efficient way to integrate high-performance AI.

When the host Raspberry Pi 5 is running an up-to-date Raspberry Pi OS image, it automatically detects the Hailo module and makes the NPU available for AI computing tasks. The built-in rpicam-apps camera applications in Raspberry Pi OS natively support the AI module, automatically using the NPU to run compatible post-processing tasks.

Disclaimer

This project is adapted from the official Raspberry Pi documentation at:
https://www.raspberrypi.com/documentation/computers/ai.html#getting-started
It is intended for third-party learning and testing of artificial intelligence neural network acceleration capabilities and does not provide any promotion or support for commercial applications. This tutorial is solely for technical enthusiasts to use for personal learning and development purposes.

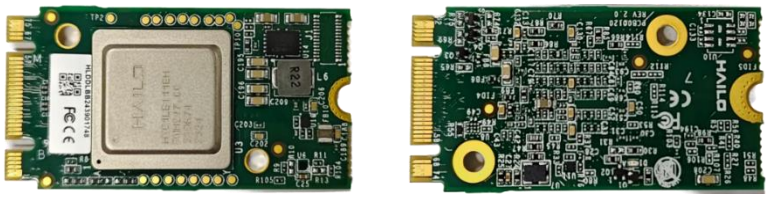
Note:

1. The configuration solution for the Hailo AI acceleration module is derived from the official Raspberry Pi website. Should the content related to the AI Kit and AI HAT+ software is removed or discontinued by the official source, we will also delete the corresponding documentation, tutorials, and code.
2. If you encounter any issues while configuring the Hailo AI acceleration module, you may submit questions regarding the module on the official Raspberry Pi forum:
https://forums.raspberrypi.com/viewforum.php?f=170
3. For more information on how to use the Hailo AI acceleration module, please refer to the "Further Resources" section at the end of the official documentation:
https://www.raspberrypi.com/documentation/computers/ai.html#further-resources

If you have any concerns, please feel free to contact us via support@freenove.com

Installing Hailo AI Acceleration Module

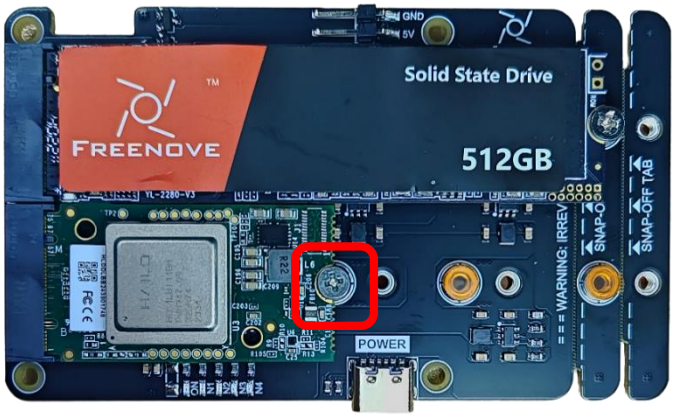
1. The following two figures show the top and bottom of the Hailo AI Acceleration Module with B+M key interface, whose size is 2242.



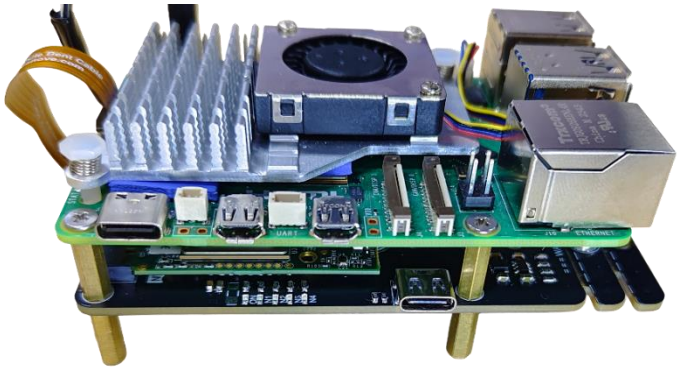
You can plug it into any NVMe interface on the 4-slot SSD Adapter Board or 2-slot SSD Adapter Board. First, tilt the module to connect.

Important Notice: The Hailo AI accelerator module utilizes a double-sided component layout. To avoid short circuits caused by contact between components and the mounting studs, do not remove the orange insulating pads on the studs. If you accidentally tear them off, please click here for solutions.

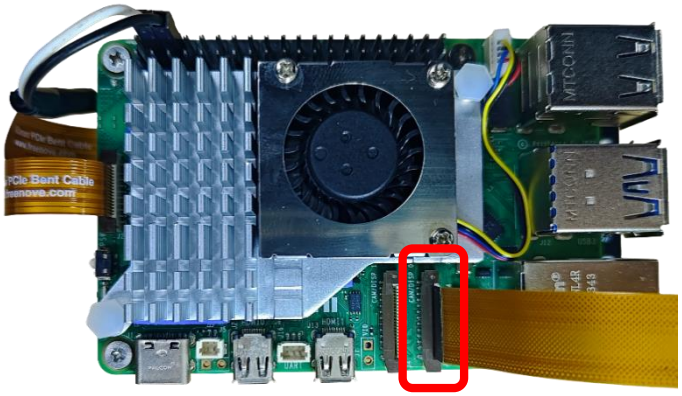
2. Fix it with an M2.5x3 screw.



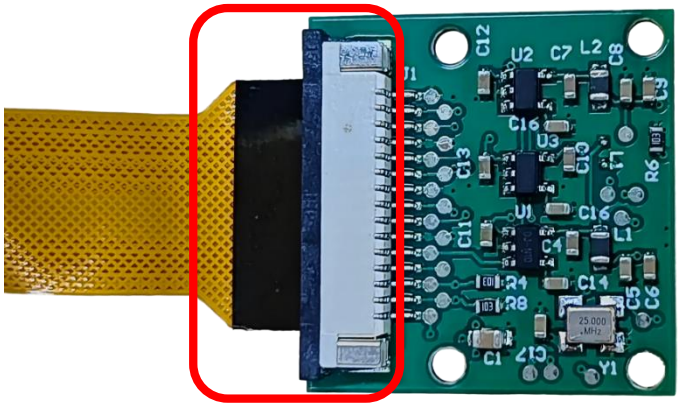
3. Assemble the SSD Adapter Board to the Raspberry Pi 5. (**For detailed steps, please refer to Chapter 2 of the Main Tutorial.**)



4. Connect the camera cable to the Raspberry Pi. (Pay attention to the cable orientation. The side with contact pins faces the USB ports.)



5. Connect the other end of the camera cable to the camera.



Hailo AI Acceleration Module Configuration & Basic Examples

This tutorial will show you how to configure the Hailo AI accelerator module to function as a Raspberry Pi's NPU. We will use the module's AI neural network acceleration capabilities with a Raspberry Pi camera to run some basic demos.
For more information about the Hailo AI accelerator module, refer to the link below:
https://www.raspberrypi.com/documentation/computers/ai.html#hardware-setup

1. Hailo AI Acceleration Module Configuration

1.1 Updating Raspberry Pi Firmware and Software Packages

To ensure your Raspberry Pi 5 runs the latest software, please run the following command in the Terminal.

```
sudo apt update && sudo apt full-upgrade
```

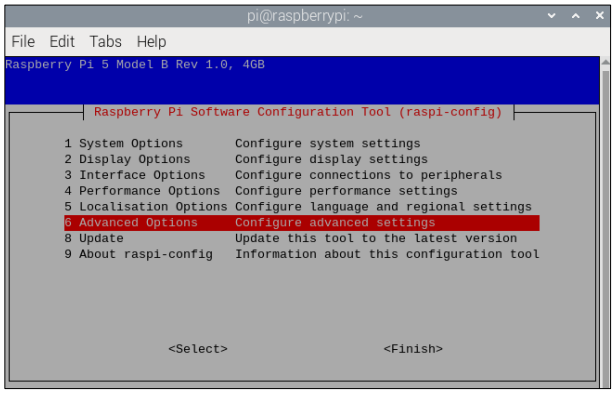
```
pi@raspberrypi:~ $ sudo apt update && sudo apt full-upgrade
Hit:1 https://mirrors.tuna.tsinghua.edu.cn/debian bookworm InRelease
Hit:2 https://mirrors.tuna.tsinghua.edu.cn/debian-security bookworm-security InRelease
Hit:3 https://mirrors.tuna.tsinghua.edu.cn/debian bookworm-updates InRelease
Hit:4 https://mirrors.tuna.tsinghua.edu.cn/raspberrypi bookworm InRelease
```

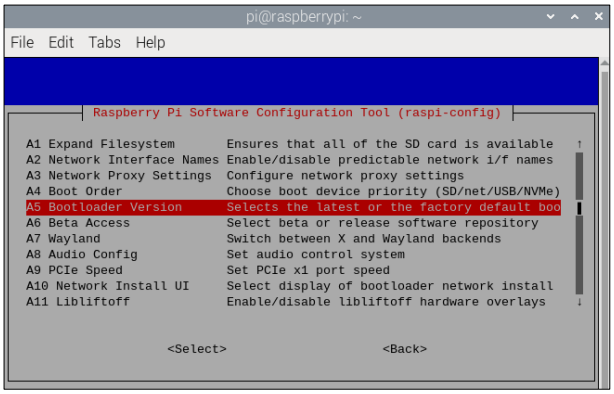
To ensure your Raspberry Pi's firmware is the latest, run the following command to update it.

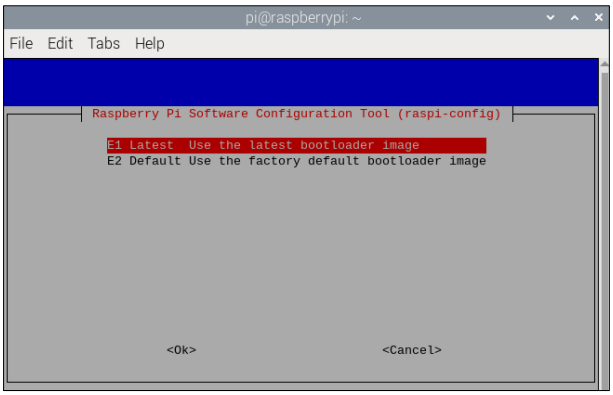
```
sudo rpi-eeprom-update
```

```
pi@raspberrypi:~ $ sudo rpi-eeprom-update
BOOTLOADER: up to date
   CURRENT: Thu  8 May 14:13:17 UTC 2025 (1746713597)
    LATEST: Thu  8 May 14:13:17 UTC 2025 (1746713597)
   RELEASE: default (/usr/lib/firmware/raspberrypi/bootloader-2712/default)
            Use raspi-config to change the release.
```

If the date displayed is later than December 6, 2023, proceed directly to the "NPU Dependencies Installation" step. If the date is earlier, follow these steps: Enter `sudo raspi-config` in the terminal, then sequentially select "6 Advanced Options" → "A5 Bootloader Version" → "E1 Latest".







After configuration, run the following command to update to the latest firmware, and then run `sudo reboot` to reboot your Raspberry Pi.

```
sudo rpi-eeprom-update -a
```

```
pi@raspberrypi:~ $ sudo rpi-eeprom-update -a
BOOTLOADER: up to date
   CURRENT: Thu  8 May 14:13:17 UTC 2025 (1746713597)
    LATEST: Thu  8 May 14:13:17 UTC 2025 (1746713597)
   RELEASE: default (/usr/lib/firmware/raspberrypi/bootloader-2712/default)
            Use raspi-config to change the release.
```

1.2 NPU Dependencies Installation

Run the following command to install the dependencies for NPU. After that, run `sudo reboot` to reboot your Raspberry Pi for the setting taking effect.

```
sudo apt install hailo-all
```

```
pi@raspberrypi:~ $ sudo apt install hailo-all
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer required:
  libbasicusageenvironment1 libgroupsock8 liblivemedia77 python3-v4l2
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  cmake cmake-data comerr-dev cppzmq-dev gdal-data gdal-plugins gir1.2-gst-plugins-bad-1.0 gir1.2-gst-plugins-base-1.0
  gir1.2-gstreamer-1.0 gir1.2-gudev-1.0 gobject-introspection gstreamer1.0-libcamera gstreamer1.0-tools hailo-tappas-core hailofw
  hailort icu-devtools ieee-data krb5-multidev libaec0 libarmadillo11 libarpack2 libavcodec-dev libavformat-dev libavutil-dev
```

After the Raspberry Pi restarts, run the following command in the terminal to verify the system status:

```
hailortcli fw-control identify
```

```
pi@raspberrypi:~ $ hailortcli fw-control identify
Executing on device: 0001:03:00.0
Identifying board
Control Protocol Version: 2
Firmware Version: 4.20.0 (release,app,extended context switch buffer)
Logger Version: 0
Board Name: Hailo-8
Device Architecture: HAILO8L
Serial Number: HLDDLBB243901748
Part Number: HM21LB1C2LAE
Product Name: HAILO-8L AI ACC M.2 B+M KEY MODULE EXT TMP
```

The information printed as shown above indicates that the NPU and its dependencies have been installed.

You can also run the following command to check the kernel log for Hailo related records:

```
dmesg | grep -i hailo
```

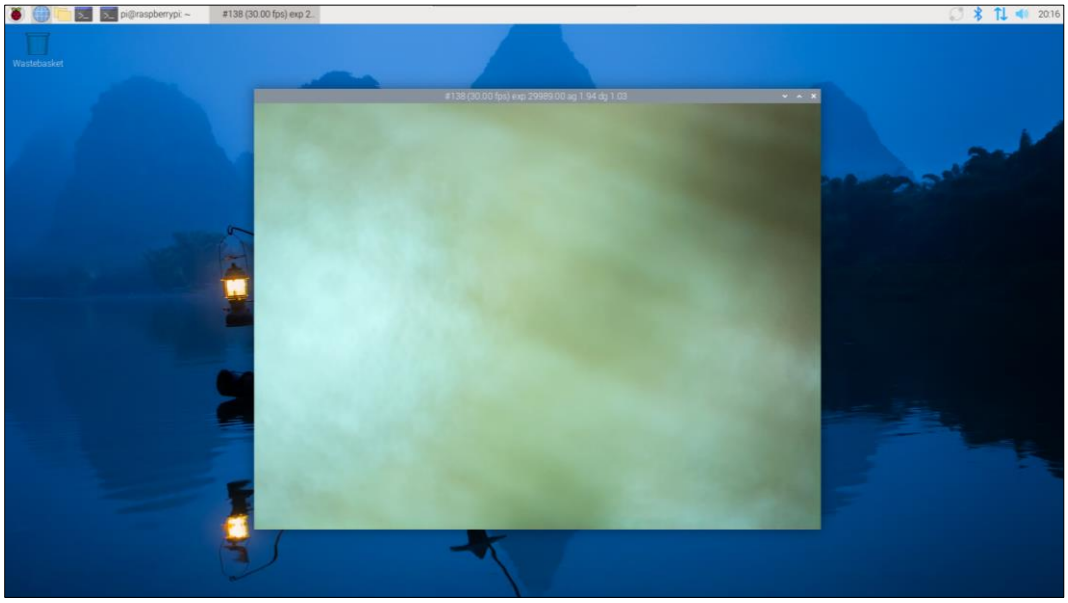
```
pi@raspberrypi:~ $ dmesg | grep -i hailo
[    1.716594] hailo: Init module. driver version 4.20.0
[    1.716668] hailo 0001:03:00.0: Probing on: 1e60:2864...
[    1.716671] hailo 0001:03:00.0: Probing: Allocate memory for device extension, 13184
[    1.716696] hailo 0001:03:00.0: enabling device (0000 -> 0002)
[    1.716703] hailo 0001:03:00.0: Probing: Device enabled
[    1.716715] hailo 0001:03:00.0: Probing: mapped bar 0 - 00000000db83623f 16384
[    1.716719] hailo 0001:03:00.0: Probing: mapped bar 2 - 000000008c2a2a25 4096
[    1.716721] hailo 0001:03:00.0: Probing: mapped bar 4 - 00000000a37f6c24 16384
[    1.716724] hailo 0001:03:00.0: Probing: Force setting max_desc_page_size to 4096 (recomme
nded value is 16384)
```

2. Basic Example Demos

With the above steps, we have successfully installed Hailo AI acceleration module's dependencies.
Before demonstration, we need to ensure that the camera is working properly and have the rpicam-apps library installed.

Run the following command to verify camera functionality. The camera preview video will last for 10s.

```
rpicam-hello -t 10s
```



Run the following command in the terminal to update software sources and install the rpicam-apps library.

```
sudo apt update && sudo apt install rpicam-apps
```

```
pi@raspberrypi:~ $ sudo apt update && sudo apt install rpicam-apps
Hit:1 https://mirrors.tuna.tsinghua.edu.cn/debian bookworm InRelease
Hit:2 https://mirrors.tuna.tsinghua.edu.cn/debian-security bookworm-security InRelease
Hit:3 https://mirrors.tuna.tsinghua.edu.cn/debian bookworm-updates InRelease
Hit:4 https://mirrors.tuna.tsinghua.edu.cn/raspberrypi bookworm InRelease
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
All packages are up to date.
Reading package lists... Done
```

2.1 Object Detection

Run the following command to view neural network detections with bounding boxes (white frame indicates recognition area) in real-time from the camera. Press Ctrl + C to exit.
Use the `-n` option to disable the viewfinder display, or add `-v 2` for text-only detection results.

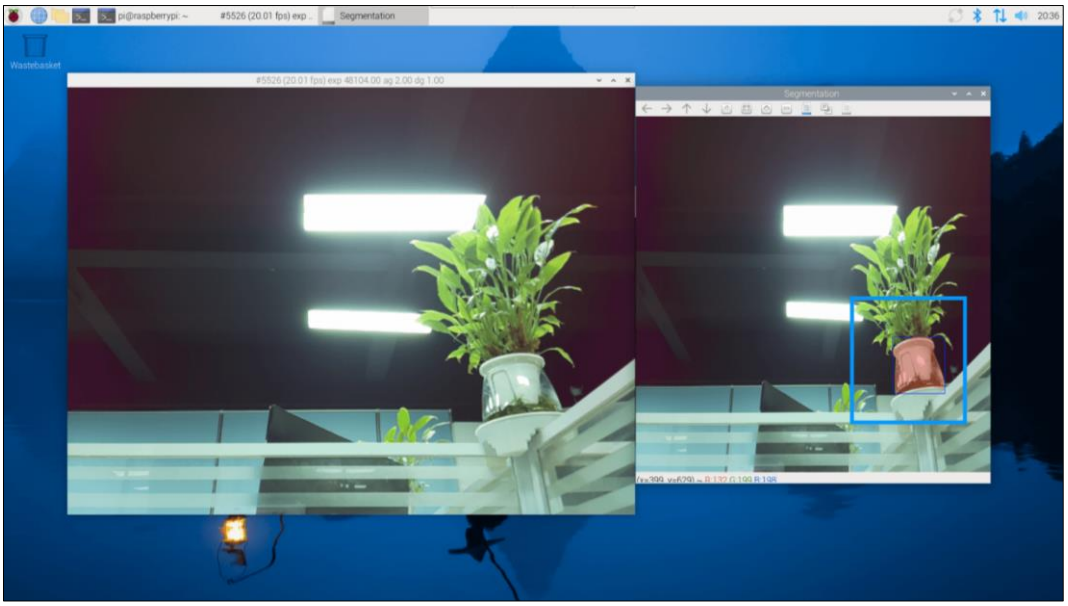
```
rpicam-hello -t 0 --post-process-file /usr/share/rpi-camera-assets/hailo_yolov6_inference.json
```

2.2 Image Segmentation

Run the following command to perform object detection and image segmentation in the viewfinder. Recognized objects (for example, the flowerpot boxed in the figure below) will be highlighted with color masks (like the blue box shown in the figure).

Press Ctrl + C to exit the program

```
rpicam-hello -t 0 --post-process-file /usr/share/rpi-camera-
assets/hailo_yolov5_segmentation.json --framerate 20
```



2.3 Pose Estimation

The following command performs real-time 17-point human pose estimation directly on your camera feed, automatically rendering skeletal connections between detected keypoints.

Press Ctrl+C to terminate the program.

```
rpicam-hello -t 0 --post-process-file /usr/share/rpi-camera-assets/hailo_yolov8_pose.json
```