

Get Started with the Raspberry Pi Al Kit

A Beginner's Guide to Al and Edge Computing



Dogan Ibrahim



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Preface

Artificial Intelligence (AI) is now part of our lives. Most microcontroller based systems are expected to include some form of AI in their future designs. In the past, AI was implemented using rather expensive and fast parallel computer structures and this technology was not available to general users. With companies developing low-cost AI powered hardware into their products, it is now becoming a reality to purchase AI accelerator hardware at comparatively very low costs. One such hardware accelerator is the Hailo module. The good news is that recently this module has been compatible with the Raspberry Pi 5 as it requires the PCIe hardware support.

The Raspberry Pi AI Kit is a cleverly designed hardware as it bundles an M.2 based Hailo-8L accelerator with the Raspberry Pi M.2 HAT+ to offer high speed inferencing on the Raspberry Pi 5.

Using the Raspberry Pi AI Kit you can build complex AI based vision applications, running in real time with low power requirements. Examples include object detection, pose estimation, instance segmentation, home automation, security, robotics, and many more neural network based applications.

The AI Kit offers 13 tera operations per second (TOPS) neural network based inference accelerator built around the Hailo08L chip. The Raspberry Pi 5 automatically detects the installed Hailo module and makes the NPU available for AI based applications.

The AI Kit hardware fully integrated with the Raspberry Pi 5 board and it is supplied with the following parts:

- Hailo AI module containing the Hailo-8L chip
- Raspberry Pi 5 M.2 HAT+ interface to connect the AI module to your Raspberry Pi 5
- Mounting kit
- GPIO header

The basic features of the AI Kit are:

- 13 TOPS neural network inference accelerator
- Fully integrated with the Raspberry Pi camera system
- Compatible with the Raspberry Pi HAT+ specification
- Thermal pad to spread heat across components
- Easy fitting to the Raspberry Pi 5

This book is an introduction to the Raspberry Pi AI Kit, and it is aimed to provide some help to readers who are new to the kit and who want to run some simple AI based visual models on their Raspberry Pi 5 computers. The book is not meant to cover the detailed process of model creation and compilation, which is done on an Ubuntu computer having a large disk

space and 32 GB memory. These are covered in detail with examples at the web sites of Hailo.

Learning to use the AI software takes a bit of learning, but it is expected that this may change as the time goes on and as the Hailo software is more integrated into the Raspberry Pi 5 operating system.

Two fully tested and working projects are given in the book. The first project explains how a person can be detected and how an LED can be activated after the detection, and how the detection can be acknowledged by pressing an external button. The second project illustrates how a person can be detected, and how this information can be passed to a smart phone over a WiFi link, and how the detection can be acknowledged by sending a message from the smart phone to Raspberry Pi 5.

The AI Kit software is new and it is currently under development and changes. The book presents the currently available software features of the kit.

The author hopes that the book becomes useful to those readers seeking to understand how to install and use the AI Kit.

Dr. Dogan Ibrahim London, 2024

Chapter 1 • The Raspberry Pi 5

1.1 Overview

Raspberry Pi 5 is the latest credit card size computer from the Raspberry Pi Foundation. In this Chapter we will look at the specifications of this new computer and compare it with the Raspberry Pi 4.

1.2 The Raspberry Pi 5 hardware

Raspberry Pi 4 was released in June 2019. There has been long wait for a newer model and finally Raspberry Pi 5 is here and will be on sale from the end of October 2023.

Raspberry Pi 5 is claimed to be two or three times the processing power of Raspberry Pi 4 which is already a very popular single board computer. Raspberry Pi 5 will initially be available in 4GB and 8GB memory capacities, although smaller memory devices will be announced later. Although the Raspberry Pi 5 is same size and shape as the Model 4B, it has a number of interesting new features such as PCIe connector, power button, built-in real-time clock, and some others that we will investigate in this Chapter.

Raspberry Pi 5 is based on 2.4GHz Cortex-A76 Arm processor with a new Southgate bridge for handling the peripheral interface. A new VideoCore VII GPU is provided with 800MHz speed. Dual camera interface is another nice feature of the Raspberry Pi 5. Another major improvement is the microSD card slot with support for high-speed SDR104 mode. In our testing, the SD card speeds were twice as fast as the last generation. This is thanks to the new RP1 southbridge developed by Raspberry Pi.

Table 1.1 shows a comparison of Raspberry Pi 4 and 5. Notice that both devices have dual 2 x 4Kp60 HDMI display interfaces although Pi 5 supports HDR output. The new Raspberry Pi 5 rocks DDR4X RAM instead of the DDR4 RAM used before. This enables the RPi 5 to have improved clock speeds with less power consumption, which is a step in the right direction. The RPi 5 can perform close to 30,000 MB writes and reads per second as compared to the Raspberry Pi 4, which can only do 4,000 to 6,000. 2×20 pin GPIO interface is the same in both devices. Raspberry Pi 5 additionally supports 2 camera interfaces, PCIe bus connector, UART interface, RTC clock power connector, and fan power connector. Wi-Fi and Bluetooth are supported by both devices. The on-board power switch on Pi 5 is a useful addition and was requested by many users. Pi 5 is powered from 5V 4A USB-C type power supply where Pi 4 is powered from a 3A power supply. Pi 5 is slightly more expensive than Pi 4.

	Raspberry Pi 4	Raspberry Pi 5	
SoC	BCM2711 SoC	BCM2712 Soc	
	Cortex-A72 CPU at 1.8 GHz	Cortex-A76 CPU at 2.4 GHz	
CPU 4 core		4 core	
Instruction set	ARMv8-A	ARMv8-2	
Display	500 MHz VideoCore Vi GPU	800 MHz VideoCore VII GPU	
L2 Cache	1 MB (shared)	2 MB	
L3 Cache	None	2 MB (shared)	
RAM	1,2,4 GB LPDDR4	4,8 GB LPDDR4X	
SD Card	microSD	microSD (high speed SDR104 compatible)	
GPIO	2 x 20 pin	2 x 20 pin	
USB ports	2 x USB2	2 x USB2	
	2 x USB3	2 x USB3	
Networking	Gigabit Ethernet port	Gigabit Ethernet port	
Connectors 2-lane MIPI display port		2 x MIPI camera	
	2-lane MIPI CSI camera port 4-pole stereo audio and	2 x 4-lane MIPI camera/display 2xPCIe 2.0 interface	
	composite video port	UART port	
		RTC clock power port	
		Fan power port	
Wi-Fi/Bluetooth 802.11ac, Bluetooth 5/BLE		802.11ac,Bluetooth 5/BLE	
Power button None		Yes	
Power 5V 3A USB-C		5V 4A USB-C	
Size 85 x 56mm		85 x 56mm	

Table 1.1 Comparison of Raspberry Pi 5 and raspberry Pi 4

There are 2 micro HDMI based monitor ports on both devices, with both having the same specifications.

The Ethernet port and USB ports are swapped. As a result of this the Raspberry Pi 4 case is not compatible with the Pi 5 case and a new case is required.

The camera and display connectors on Raspberry Pi 5 are 15-pin and smaller instead of the original 22-pin connector used on Pi 4. A ribbon cable with 22-pin on one side and 15-pin on the other side is required to connect an existing Raspberry Pi 4 camera to Raspberry Pi 5. Raspberry Pi 5 has two connectors, allowing two cameras or DSI displays (or a mix of either) to be connected. The PCIe connector is for fast external PCIe compatible peripherals, such as SSDs.

The new power button on Raspberry Pi 5 could be very useful. When the device is On, pressing the button brings the shutdown (logout) menu. A safe shutdown will occur with another press of the power button.

Figure 1.1 shows the front view of the Raspberry Pi 5 with the components labelled for reference.

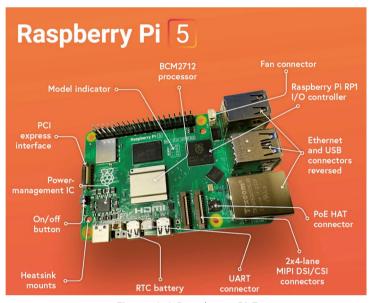


Figure 1.1 Raspberry Pi 5

While the Raspberry Pi 4 and 5 share a similar form factor (e.g., same size: $85 \text{mm} \times 56 \text{mm}$), the Pi 5 has many subtle differences that can be seen at first glance. For example, the USB and Ethernet ports are in reverse order. A Raspberry Pi 5 looks more like a Pi 3B+ from this angle (see Figure 1.2).



Figure 1.2 RPI 4 (left) and RPI 5 (right)

1.3 Active cooler

The Raspberry Pi 5 gets very hot and it is recommended to use an active cooler to lower the CPU temperature. Although the idle CPU temperature is around 50 degrees Celsius, it can go higher than 85 degrees under a stress test. An active cooler is available for Raspberry Pi 5. Holes and power points are provided on the board to install and power the active cooler. Figure 1.3 shows the Raspberry Pi 5 with the recommended official active cooler installed.

The specifications of this active cooler are:

Input voltage: 5 V DC supplied via four-pin fan header on Raspberry Pi 5 board

Fan speed control: Pulse width modulation control with tachometer

Maximum airflow: 1.09 CFM **Material**: anodised aluminium

The active cooler cools down the SoC, RAM, and the Southgate chipset. Without any cooling, the Raspberry Pi 5 idle temperature is about 65°C. With the cooler, when the temperature is 60°C the blower's fan turns on. At 67.5°C the fan speed is increased, and at 75°C the fan speed increases to its maximum. When the temperature drops, the fan speed also drops automatically. You can mount a HAT above the Active Cooler using a set of 16mm GPIO extenders. Inevitably there is some disruption to the air flow which will cause the Raspberry Pi to run hotter, but the Active Cooler is still able to handle extended stress tests without significant temperature rises.

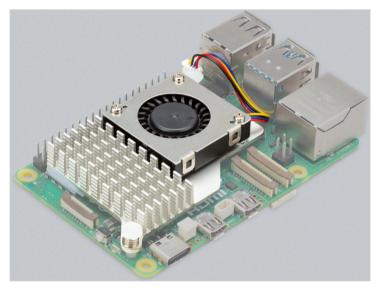


Figure 1.3 Raspberry Pi 5 with active cooler

1.4 Raspberry Pi 5 Operating System

Raspberry Pi 5 OS is based upon Debian 12 with the codename **Bookworm**. This OS, released in July 2023, comes with a new Python interpreter (Python 3.11). A new change is that a Python package cannot be installed using the **pip** commands. Also, Bookworm operating system uses the Wayland rather than X11 as the display system. For many years, or most Unix desktop environments, including the Raspberry Pi Desktop, have been based on the X11 window system which has several limitations.

Another major software change in Bookworm is that the RPi.GPIO (created by Ben Croston) was not available at the time of writing this book. As a result of this, all of the GPIO based Python programs in the book have been developed using the **gpiozero**. Most third-party

HATs are based on the RPi.GPIO and these will not work until their software is changed by their manufacturers. It is hoped that the manufacturers will change their software by the time Raspberry Pi 5 becomes officially widely available.

ALSA was the original audio interface on Raspberry Pi computers. PulseAudio then has replaced the ALSA interface which was still sitting on top of the low-level ALSA interface. This made it easier to manage things like Bluetooth audio devices, allowed audio from multiple applications to be mixed together, and allowed audio to easily be switched between outputs while playing. In Bookworm, PulseAudio has been replaced with the newer PipeWire_audio system. This new system manages audio applications, remember the ones used at power-down, and automatically connects them at reboot time. From a user point of view, both the PulseAudio and PipeWire look identical.

1.5 Benchmarks

Figure 1.4 and Figure 1.5 show the overall benchmark scores of the Raspberry Pi 5 and Raspberry Pi 4 with both having 8 GB of memory, which clearly indicate that the Raspberry Pi 5 is two to three times faster than its predecessor in all types of tests. In these tests, same SD card, same power supply, and same cooling environments were used.



Figure 1.4 Geekbench 5 benchmark scores for the Raspberry Pi 5 (Geekbench)

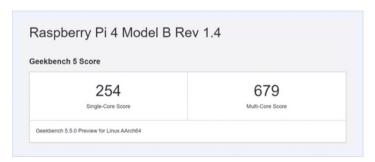


Figure 1.5 Geekbench 5 benchmark scores for the Raspberry Pi 4 (Geekbench)

The **ncnn** framework (neural network models) tests from *Seeed Studio* show in Figure 1.6 the power of the Raspberry Pi 5 compared to Raspberry Pi 4. Note here that smaller numbers are better.