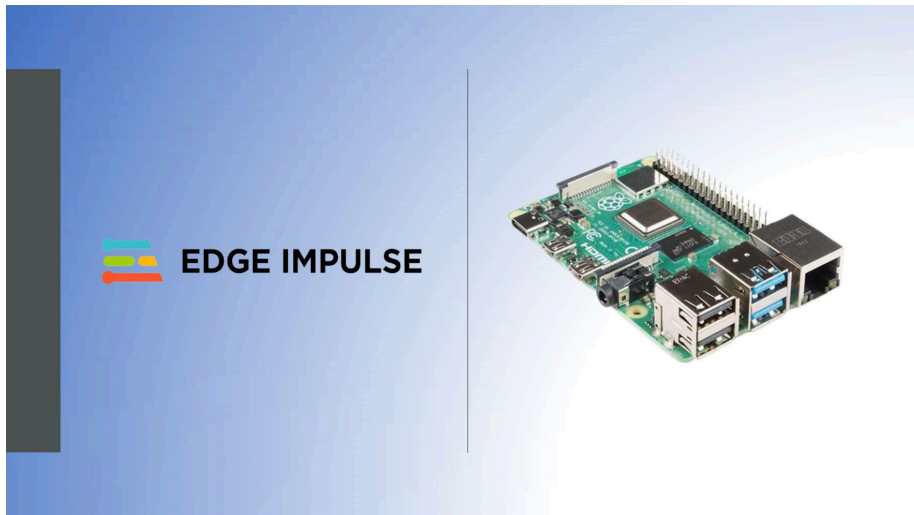


[Holiday Announcement] We will be closed for the Raya holiday from March 29 to April 6. Orders placed after March 28 at 12 PM (GMT +8) will be processed starting April 7. Thank you for your understanding.

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Tags

[Edgeimpulse](#)[Machine learning](#)[Raspberry Pi](#)[Camera](#)[Object classification](#)[Raspberry Pi](#)

Object Classification with Edge Impulse Using Raspberry Pi 4 and Camera Module

[Khor Jia Yong](#) 02 Jan 2024

7



Project Intermediate 1889

Introduction

The primary emphasis of this project lies in object classification or recognition. This involves identifying various objects during the capturing process. To construct this, Edge Impulse functions as a machine learning platform, training Raspberry Pi 4 to recognise different object types when connected to a camera.

Hardware Components

- Raspberry Pi 4 Model B

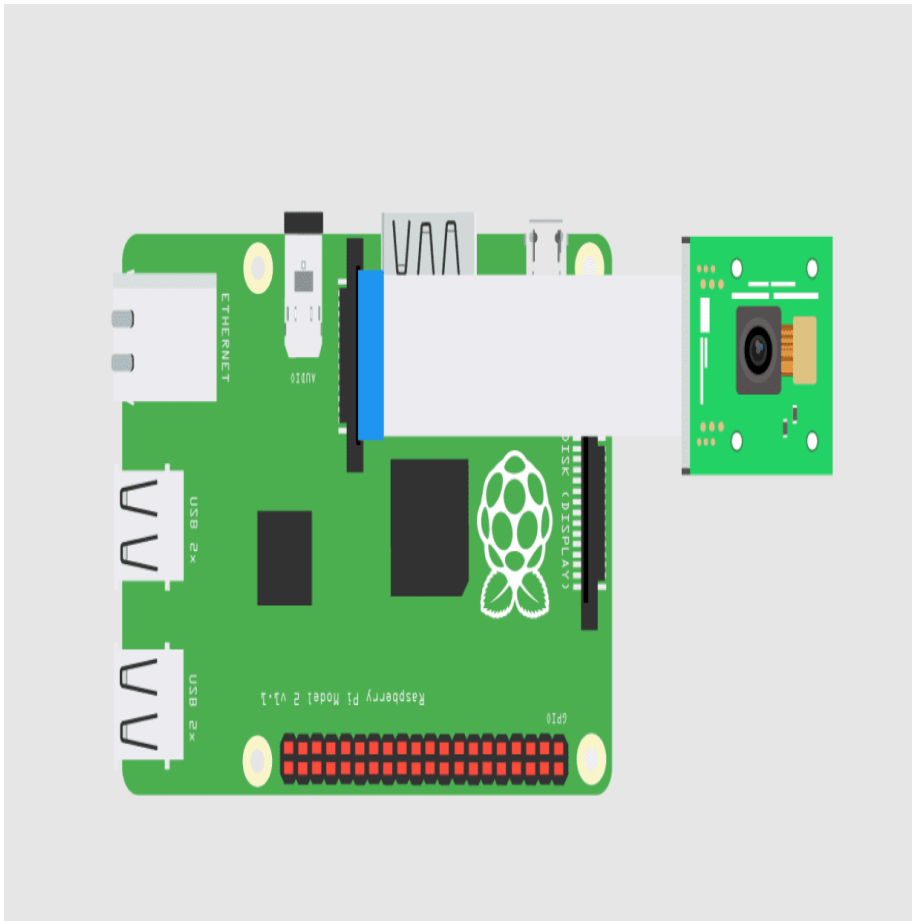
Software Requirement

- [Raspberry Pi Imager](#)

Project Development

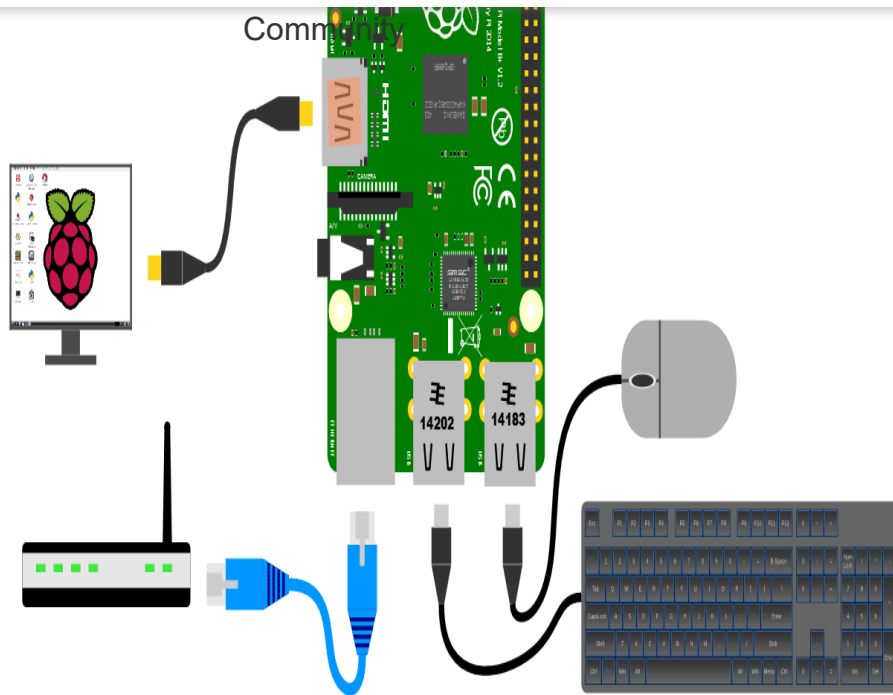
Hardware Part

i. Connect the Raspberry Pi camera module to the camera port available on the Raspberry Pi 4 with a ribbon cable.



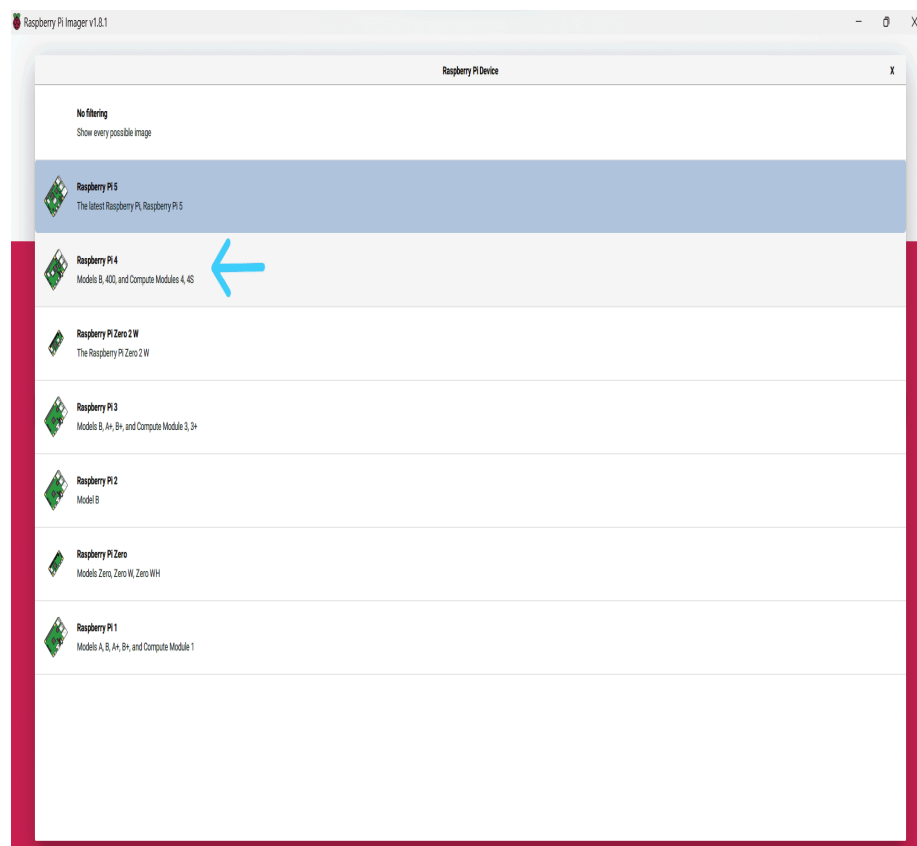
ii. For additional information regarding the connection, refer to this [documentation](#).

iii. Set up your Raspberry Pi 4 device by connecting the mouse, keyboard as well as monitor to the Raspberry Pi 4.











Software Part

i. Flash the Raspberry Pi OS into the microSD card by choosing the Raspberry Pi 4 device and Raspberry Pi OS with Full Legacy 64-bits.

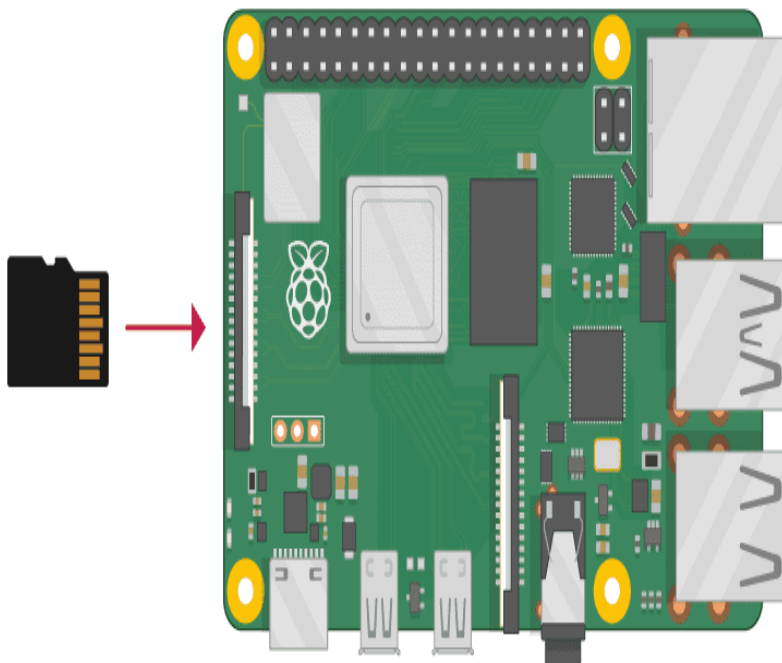


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	Raspberry Pi OS (Legacy) 64-bit Full A port of Debian Bullseye with security updates, desktop environment and recommended applications Released: 2023-05-03 Online - 2.5 GB download



ii. After successfully flashing the Raspberry Pi OS into the microSD card, insert the SD card into the Raspberry Pi 4.



iii. Initialise your new Raspberry Pi OS by filling in several details on the setup page.

iv. If you haven't linked the Raspberry Pi 4 using a LAN cable, connect it to your WiFi network and click the

the sequence provided in the table below.

Community

No.	Command
1	<code>sudo apt update</code>
2	<code>curl -sL https://deb.nodesource.com/setup_12.x sudo bash -</code>
3	<code>sudo apt install -y gcc g++ make build-essential nodejs sox gstreamer1.0-tools gstreamer1.0-plugins-good gstreamer1.0-plugins-base gstreamer1.0-plugins-base-apps</code>
4	<code>npm config set user root && sudo npm install edge-impulse-linux -g --unsafe-perm</code>

vi. Refer to the [datasheet](#) of the camera module and determine the model sensor type of the camera module you are using in the project.

Net price	\$25	Community	\$25	\$35	\$50
Size	Around 25 x 24 x 9 mm	Around 25 x 24 x 9 mm	Around 25 x 24 x 11.5 mm	Around 25 x 24 x 12.4 mm	38 x 38 x 18.4mm (excluding lens)
Weight	3g	3g	4g	4g	
Still resolution	5 Megapixels	8 Megapixels	11.9 Megapixels	11.9 Megapixels	12.3 Megapixels
Video modes	1080p30, 720p60 and 640 x 480p60/90	1080p47, 1640 x 1232p41 and 640 x 480p206	1080p50 / 720p100 / 640 x 480p120	1080p50 / 720p100 / 640 x 480p120	2028 x 1080p50, 2028 x 1520p40 and 1332 x 990p120
Sensor	OmniVision OV5647	Sony IMX219	Sony IMX708	Sony IMX708	Sony IMX477]
Sensor resolution	2592 x 1944 pixels	3280 x 2464 pixels	4608 x 2592 pixels	4608 x 2592 pixels	4056 x 3040 pixels
Sensor image area	3.76 x 2.74 mm	3.68 x 2.76 mm (4.6 mm diagonal)	6.45 x 3.63mm (7.4mm diagonal)	6.45 x 3.63mm (7.4mm diagonal)	6.287mm x 4.712 mm (7.9mm diagonal)
Pixel size	1.4 μm x 1.4 μm	1.12 μm x 1.12 μm	1.4 μm x 1.4 μm	1.4 μm x 1.4 μm	1.55 μm x 1.55 μm
Optical size	1/4"	1/4"	1/2.43"	1/2.43"	1/2.3"
Focus	Fixed	Adjustable	Motorized	Motorized	Adjustable
Depth of field	Approx 1 m to ∞	Approx 10 cm to ∞	Approx 10 cm to ∞	Approx 5 cm to ∞	N/A
Focal length	3.60 mm +/- 0.01	3.04 mm	4.74 mm	2.75 mmm	Depends on lens
Horizontal Field of View (FoV)	53.50 +/- 0.13 degrees	62.2 degrees	66 degrees	102 degrees	Depends on lens
Vertical Field of View (FoV)	41.41 +/- 0.11 degrees	48.8 degrees	41 degrees	67 degrees	Depends on lens
Focal ratio (F-Stop)	F2.9	F2.0	F1.8	F2.2	Depends on lens
Maximum exposure times (seconds)	6	11.76	112	112	670.74
Lens Mount	N/A	N/A	N/A	N/A	CS- or M12-mount

vii. To interface your camera module into the Raspberry Pi, command this in the terminal:

sudo nano /boot/config.txt

viii. Add the command to the configuration text file depending on your model sensor type.

dtoverlay=imx708



Community

File Edit Tabs Help

GNU nano 5.4

```
# no display
#config_hdmi_boost=4

# uncomment for composite PAL
#sdtv_mode=2

#uncomment to overclock the arm. 700 MHz is the default.
#arm_freq=800

# Uncomment some or all of these to enable the optional hardware interfaces
#dtparam=i2c_arm=on
#dtparam=i2s=on
#dtparam=spi=on

# Uncomment this to enable infrared communication.
#dtoverlay=gpio-ir,gpio_pin=17
#dtoverlay=gpio-ir-tx,gpio_pin=18

# Additional overlays and parameters are documented /boot/overlays/README

# Enable audio (loads snd_bcm2835)
dtparam=audio=on

# Automatically load overlays for detected cameras
start_x=1

# Automatically load overlays for detected DSI displays
display_auto_detect=1

# Enable DRM VC4 V3D driver
#dtoverlay=vc4-kms-v3d
max_framebuffers=2

# Run in 64-bit mode
arm_64bit=1

# Disable compensation for displays with overscan
disable_overscan=1

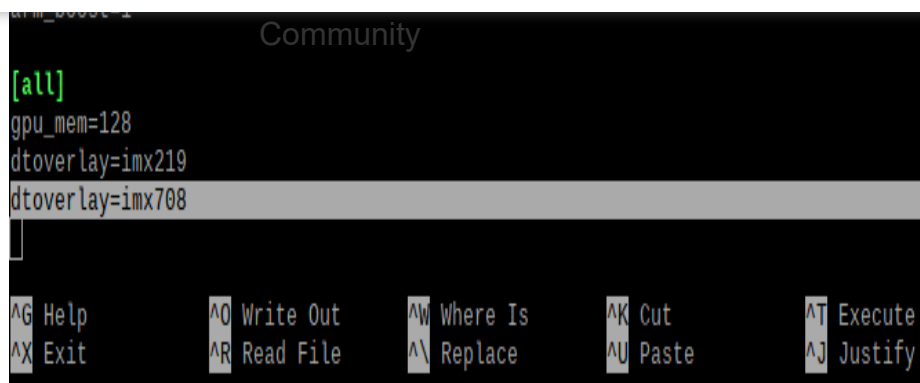
[cm4]
# Enable host mode on the 2711 built-in XHCI USB controller.
# This line should be removed if the legacy DWC2 controller is required
# (e.g. for USB device mode) or if USB support is not required.
otg_mode=1
```

[all]

Tutorials

[pi4]





```
Community

[all]
gpu_mem=128
dtoverlay=imx219
dtoverlay=imx708

^G Help      ^O Write Out  ^W Where Is   ^K Cut        ^T Execute
^X Exit      ^R Read File  ^\ Replace    ^U Paste      ^J Justify
```

(Because the sensor type is the Raspberry Pi camera module 3, specifically imx708, it is designated to the variable "dtoverlay.")

- ix. Press "Ctrl + X" -> "Ctrl + Y" -> "ENTER" to save the edit.
- x. Reboot your Raspberry Pi device.

Edge Impulse Part

- i. Create a new project on your Edge Impulse.
- ii. Open the terminal and enter the command below to enable the connection between Edge Impulse and Raspberry Pi.

edge-impulse-linux --clean

- iii. Fill in the details and select the project you created on the Edge Impulse.

Community

File Edit Tabs Help

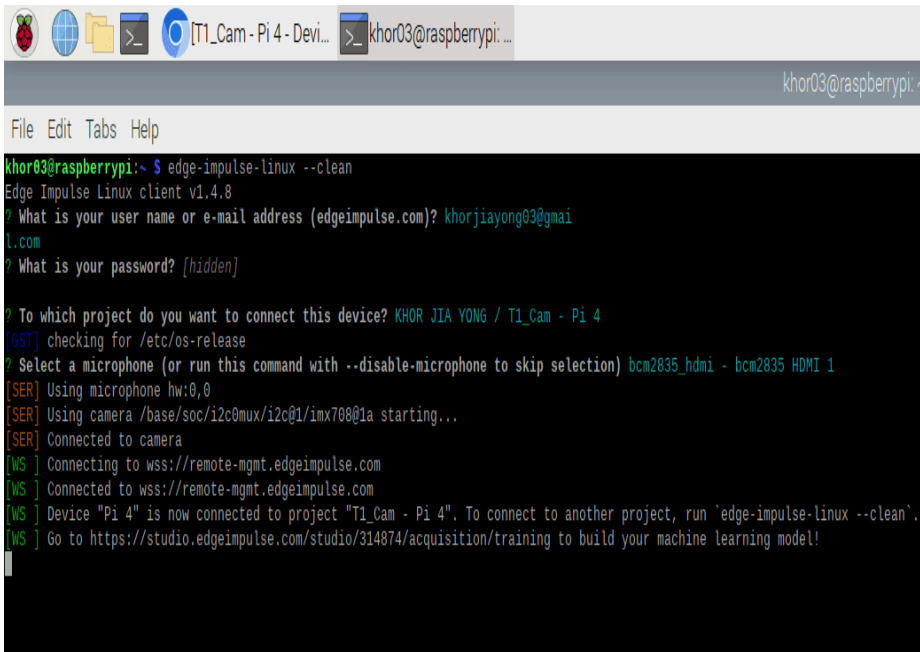
```
kh03@raspberrypi:~$ edge-impulse-linux --clean
Edge Impulse Linux client v1.4.8
? What is your user name or e-mail address (edgeimpulse.com)? kh03@gmail.com
? What is your password? [hidden]
? To which project do you want to connect this device?
KH03 JIA YONG / P1_Built in microphone
KH03 JIA YONG / P2_Accelerometer
KH03 JIA YONG / Attempt 1_Arduino IDE
KH03 JIA YONG / P3_ADC
KH03 JIA YONG / Attempt 3_Mic
KH03 JIA YONG / P3_Ultrasonic
KH03 JIA YONG / Attempt 5_CAM
KH03 JIA YONG / Attempt 6_Accelerometer
KH03 JIA YONG / Attempt 7_Data forward
KH03 JIA YONG / P3_Combination
KH03 JIA YONG / P2_Positional
KH03 JIA YONG / P2_Camera
KH03 JIA YONG / P2_Mic
KH03 JIA YONG / Attempt 9_Data forward-Potentiometer
KH03 JIA YONG / Attempt 10 _Data forward combine
KH03 JIA YONG / P3_Mic
KH03 JIA YONG / P3_Mic (Gesture / ADC)
KH03 JIA YONG / P3_Mic(Data forwarder II)
KH03 JIA YONG / P3_Mic Arduino Nano 33 BLE
> KH03 JIA YONG / T1_Cam - Pi 4
```

iv. Select your sensor type where the HDMI type is chosen.

```
File Edit Tabs Help Community
khor03@raspberrypi:~ $ edge-impulse-linux --clean
Edge Impulse Linux client v1.4.8
? What is your user name or e-mail address (edgeimpulse.com)? khorjiayong03@gmail.com
? What is your password? [hidden]

? To which project do you want to connect this device? KHOR JIA YONG / T1_Cam - Pi 4
[BS] checking for /etc/os-release
? Select a microphone (or run this command with --disable-microphone to skip selection) (Use arrow keys)
> bcm2835_hdmi - bcm2835 HDMI 1
bcm2835_headpho - bcm2835 Headphones
```

v. The figure below shows the successful connection between the Raspberry Pi and Edge Impulse.



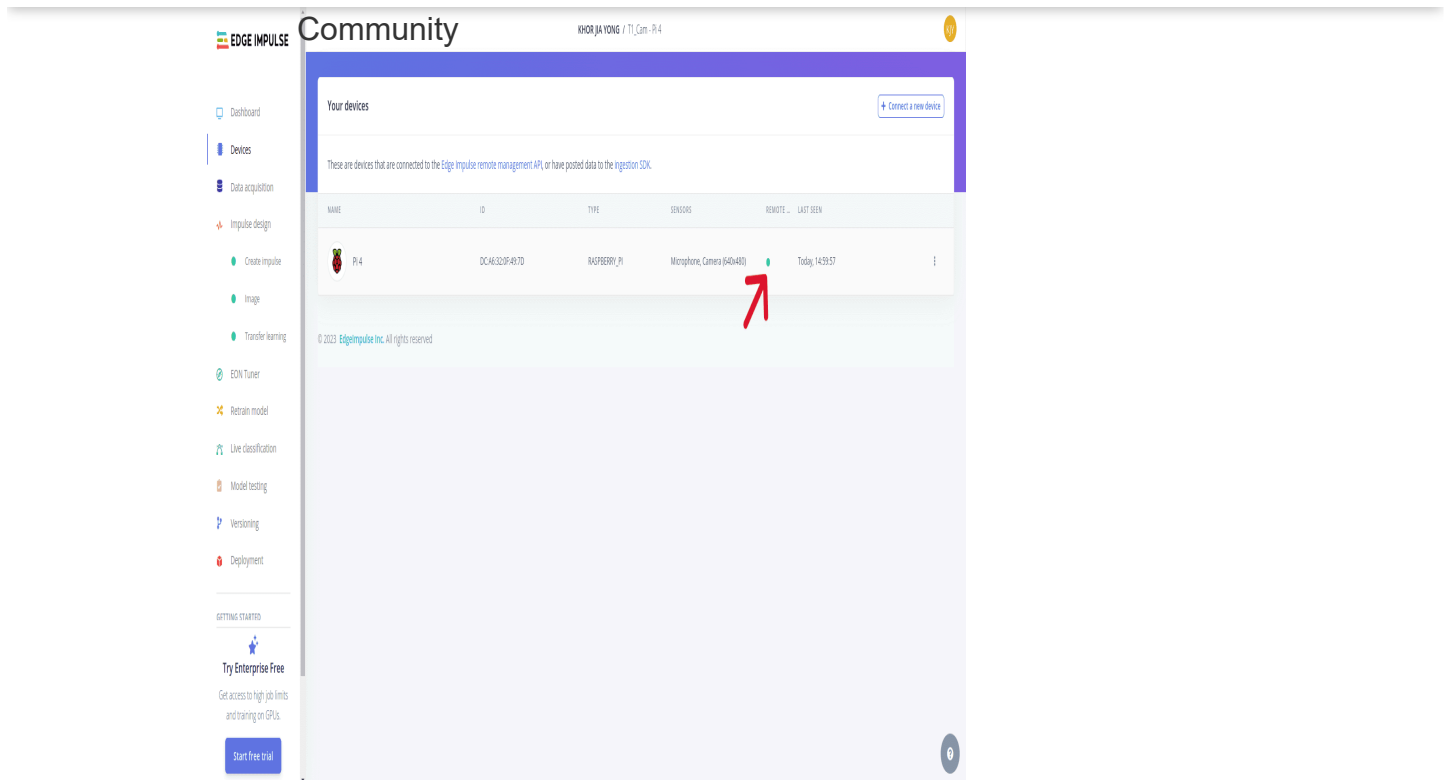
```
File Edit Tabs Help
khor03@raspberrypi:~ $ edge-impulse-linux --clean
Edge Impulse Linux client v1.4.8
? What is your user name or e-mail address (edgeimpulse.com)? khorjiayong03@gmail.com
? What is your password? [hidden]

? To which project do you want to connect this device? KHOR JIA YONG / T1_Cam - Pi 4
[BS] checking for /etc/os-release
? Select a microphone (or run this command with --disable-microphone to skip selection) bcm2835_hdmi - bcm2835 HDMI 1
[SER] Using microphone hw:0,0
[SER] Using camera /base/soc/i2c0mux/i2c@1/imx708@1a starting...
[SER] Connected to camera
[WS] Connecting to wss://remote-mgmt.edgeimpulse.com
[WS] Connected to wss://remote-mgmt.edgeimpulse.com
[WS] Device "Pi 4" is now connected to project "T1_Cam - Pi 4". To connect to another project, run 'edge-impulse-linux --clean'.
[WS] Go to https://studio.edgeimpulse.com/studio/314874/acquisition/training to build your machine learning model!
```

vi. Within Edge Impulse, there are five stages to be taken into account:

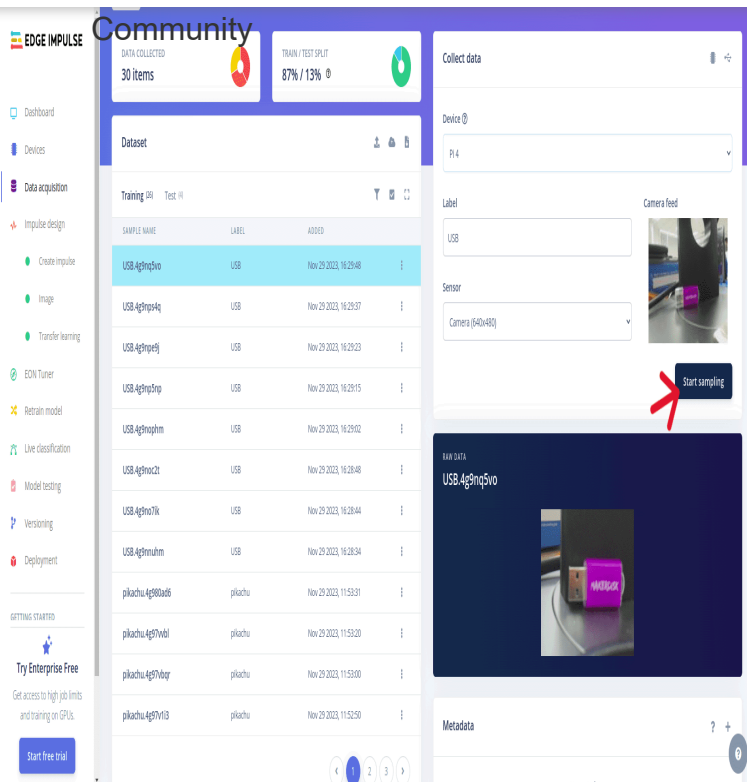
a. Device

- When the icon of Raspberry Pi turns from red colour to green colour, this indicates that the Raspberry Pi 4 device is successfully linked to the Edge Impulse.



b. Data Acquisition

- The sensor type of camera is chosen from the list and the sample length can be adjusted on the same page.
- When the “Start sampling” is clicked, the data for capturing objects from the camera module is recorded. For example, the data collection included “pikachu”, “USB” and “gamepad” in this case.
- By changing the "label" of the data, the data type can be modified.
- Then, the data collected is uploaded and saved to the same data acquisition page.

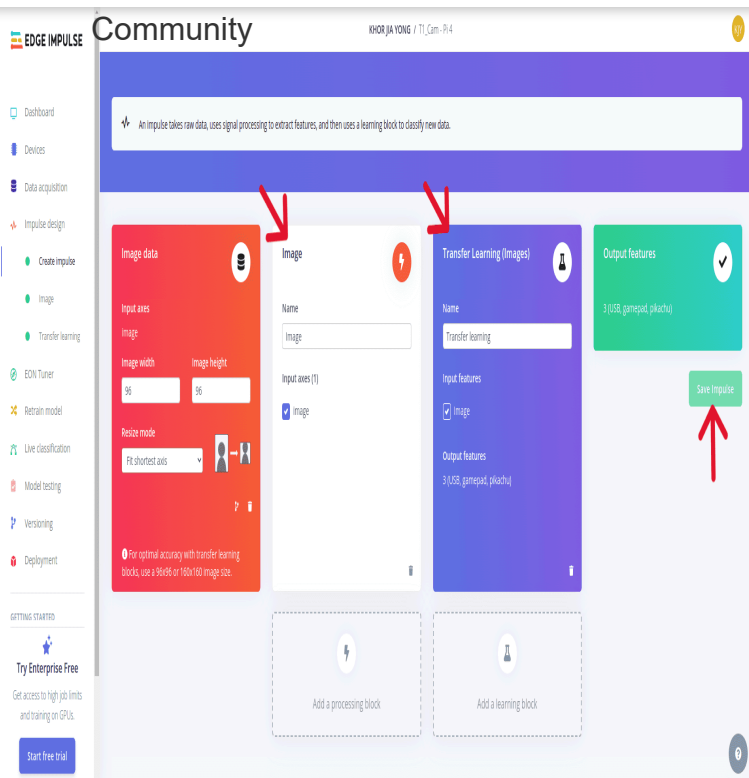


The screenshot shows the Edge Impulse Community interface. On the left is a sidebar with navigation options: Dashboard, Devices, Data acquisition, Impulse design, Create impulse, Image, Transfer learning, ECN Tuner, Retrain model, Live classification, Model testing, Versioning, and Deployment. The main area is titled 'Community' and shows a dataset of 30 items. A table lists training and test samples with columns for Sample Name, Label, and Added date. The 'Collect data' section on the right shows a device selection dropdown set to 'Pi 4', a label dropdown set to 'USB', and a sensor dropdown set to 'Camera (540x480)'. A 'Start sampling' button is highlighted with a red arrow. Below this is a 'RAW DATA' section showing a video feed of a USB drive being processed. At the bottom, there is a 'Metadata' section with a search bar and a plus icon.

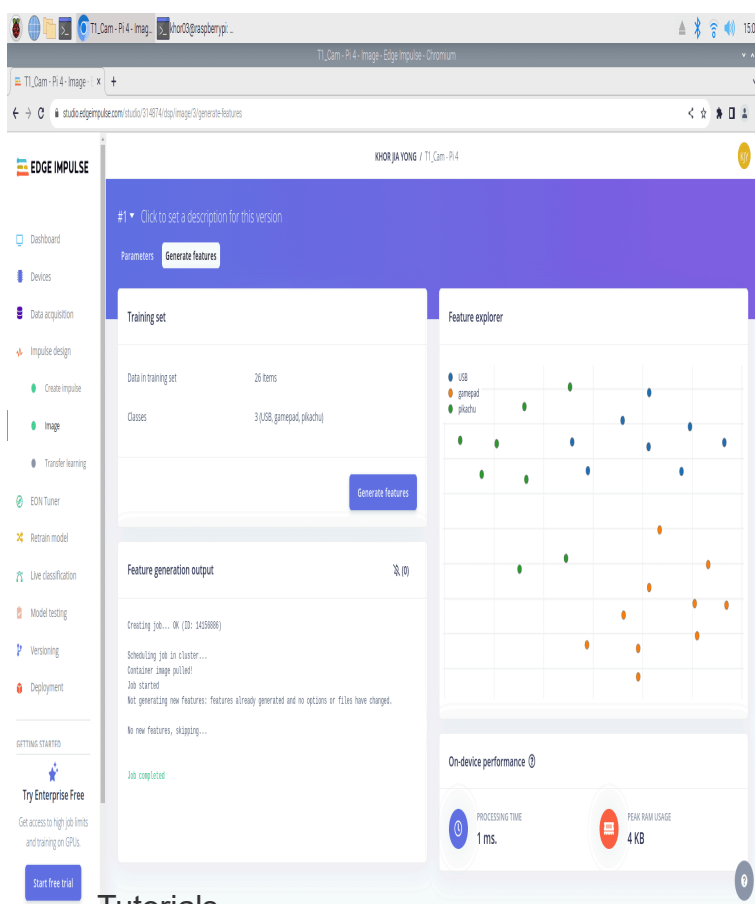
Training	Test	Label	Added
USB-AgImpvivo	USB	Nov 29 2023, 16:29:48	
USB-AgImpv1q	USB	Nov 29 2023, 16:29:57	
USB-AgImpv1j	USB	Nov 29 2023, 16:29:53	
USB-AgImpv1p	USB	Nov 29 2023, 16:29:55	
USB-AgImpv1m	USB	Nov 29 2023, 16:29:52	
USB-AgImpv2t	USB	Nov 29 2023, 16:29:48	
USB-AgImpv1k	USB	Nov 29 2023, 16:29:44	
USB-AgImpv1h	USB	Nov 29 2023, 16:29:54	
pi-kachu-Ag80x86	pi-kachu	Nov 29 2023, 11:53:31	
pi-kachu-Ag57v0d	pi-kachu	Nov 29 2023, 11:53:20	
pi-kachu-Ag57v0p	pi-kachu	Nov 29 2023, 11:53:00	
pi-kachu-Ag57v1d	pi-kachu	Nov 29 2023, 11:52:50	

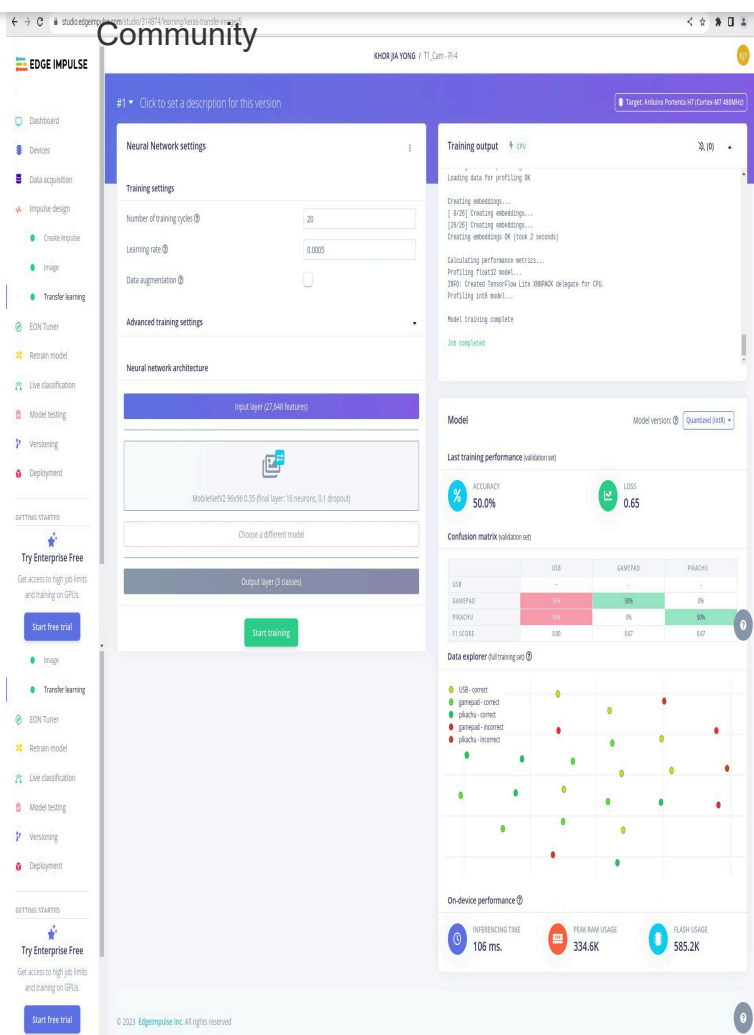
c. Impulse Design

- Graphical representation, be it in a chart or table, requires setting up the impulse or feature first by selecting from the recommended list. For instance, create two block models: a processing block and a learning block, with one block allowed for each category. Remember to save the created impulse.



- Each created impulse must be accessed and trained independently.

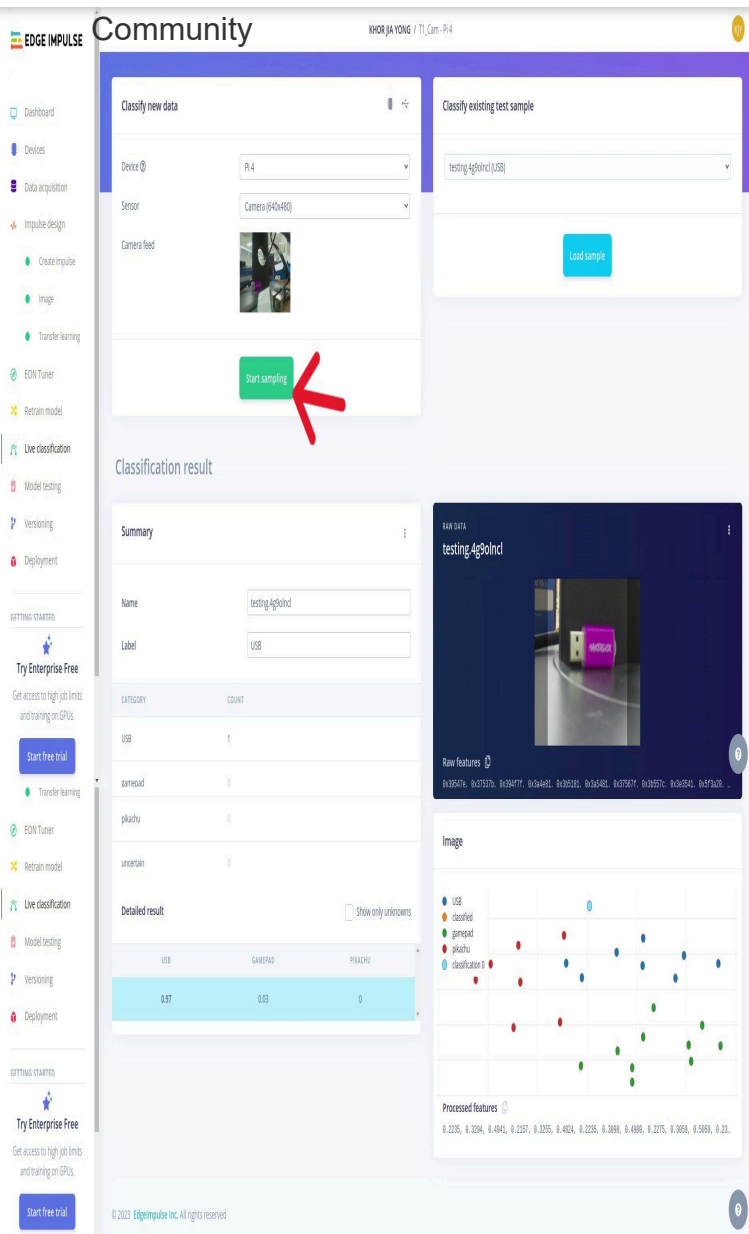




d. Live Classification


- In the live classification category, users can verify data collected using the camera module to gather and classify test data by clicking "Start sampling". Be sure to label each test data with its expected outcome.





Community KHOR JA YONG / T1_Cam - Pi4

Classify new data

Device: Pi4
Sensor: Camera (H4440)
Camera feed: 

Start sampling (indicated by a red arrow)

Classify existing test sample

testing-ajg9dnc1(USB)
Load sample

Classification result

Summary

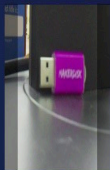
Name: testing-ajg9dnc1
Label: USB

CATEGORY	COUNT
USB	1
gamepad	0
pi4chu	0
unertain	0

Detailed result ☐ Show only unknowns

USB	GAMEPAD	PI4CHU
0.97	0.03	0

RAW DATA testing-ajg9dnc1



Raw features: 0.095476, 0.075370, 0.070477, 0.044482, 0.065193, 0.046811, 0.075877, 0.005570, 0.065542, 0.079208

Image

Legend: USB (blue), classified (orange), gamepad (green), pi4chu (red), classification 0 (light blue)

Processed features: 0.2235, 0.3294, 0.4842, 0.2257, 0.3255, 0.4824, 0.2235, 0.3889, 0.4888, 0.2275, 0.3859, 0.5889, 0.23


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e. Model Testing

- By clicking "Classify all", model testing characterises test data using graphical charts. After testing, observe the output through the provided chart.

Resource Hubs





Community

KHOJ JIA YONG / T1_Cam_P14

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Data acquisition

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Create impulse

Image

Transfer learning

EON Tuner

Retrain model

Live classification

Model testing

Versioning

Deployment

GETTING STARTED

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This lists all test data. You can manage this data through [Data acquisition](#).

Test data

Set the 'expected outcome' for each sample to the desired outcome to automatically score the impulse.

SAMPLE NAME	EXPECTED OUTCOME	LENGTH	ACCURACY	RESULT
testing-Agfa3d9c	usb	-	100%	1 usb
testing-Agfa79d6	gamepad	-	100%	1 gamepad
testing-Agfa2d8d	pikachu	-	100%	1 pikachu
testing-Agfa15d1	pikachu	-	0%	1 uncertain

Model testing output

Logging resources for test data...
 Copying features from DSP block OK
 Copying features from processing blocks OK

Classifying data for float32 model...
 Scheduling job in cluster...
 Container image pulled!
 Job started
 INFO: Created TensorFlow Lite JEMMACK delegate for CPU.
 Classifying data for Transfer Learning OK

Job completed

Model testing results

ACCURACY
75.00%

	USB	GAMEPAD	PIKACHU	UNCERTAIN
USB	100%	0%	0%	0%
GAMEPAD	0%	100%	0%	0%
PIKACHU	0%	0%	100%	0%
F1 SCORE	1.00	1.00	0.67	0%

Feature explorer

USB - correct

vii. To run the building machine model locally, consider the command below.

edge-impulse-linux-runner

[illegible]

Community

Community



Raspberry Pi Approved MakerDisk microSD Card wi...

\$11.00++

x 1 unit(s)



Raspberry Pi 4 Model B 4GB and Kits

\$60.50++

x 1 unit(s)

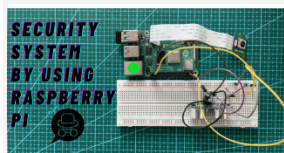


Raspberry Pi Camera Module 3 - 12MP with Auto F...

\$27.50++

x 1 unit(s)

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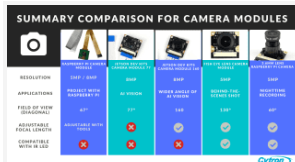


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Idteoh, 10 Mar 2022

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Idris Zainal
Abidin, 02 Sep 2021

Edge Impulse is a platform that allows us to build projects related to machine learning on microcontrollers. This tutorial will be divided into a few parts, and

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Introduction to Edge Impulse

Khor Jia Yong,
27 Dec 2023

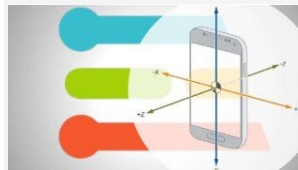
Edge Impulse guides embedded machine learning, helping developers optimize solutions with real-world data. It speeds up deployment, benefiting various industries...

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Voice Recognition with Edge Impulse Using Computer Application

Khor Jia Yong,
29 Dec 2023

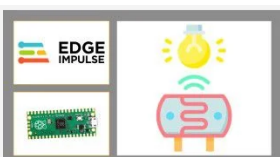
Edge Impulse empowers computer devices to function in their surroundings. In this setup, the computer serves as the primary tool for gathering data and deploying machine learning models...

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Edge Impulse with Mobile Phone Application Using Accelerometer

Khor Jia Yong, 03 Jan 2024

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Impulse with Raspberry Pi Pico Application Using ADC Light Sensor

Khor Jia Yong,
08 Jan 2024

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Impulse with Raspberry Pi Pico Application Using Ultrasonic Sensor

Khor Jia Yong,
17 Jan 2024

Edge Impulse now supports devices with the RP2040 chip. The project uses the Raspberry Pi Pico with the RP2040 chip to create an ultrasonic ranger for distance measurement...

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Detection with Edge Impulse Using Mobile Phone

Khor Jia Yong,
24 Jan 2024

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