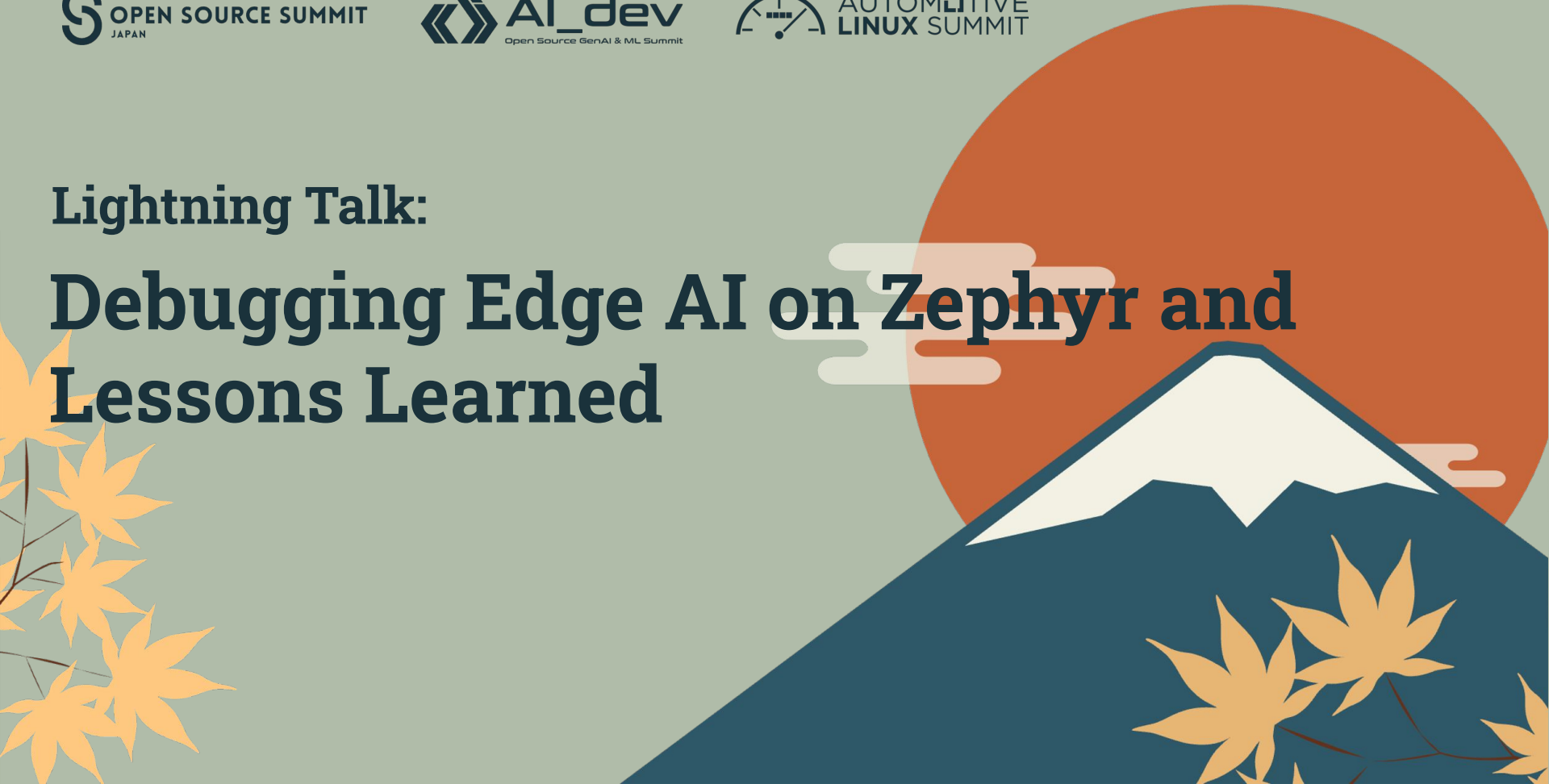
THE LINUX FOUNDATION OPEN SOURCE SUMMIT JAPAN

AI_dev Open Source GenAI & ML Summit

AUTOMOTIVE LINUX SUMMIT

Lightning Talk:

Debugging Edge AI on Zephyr and Lessons Learned



About Me

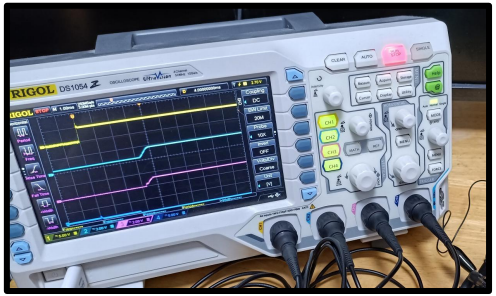
I am a Hardware and Hobbyist Engineer

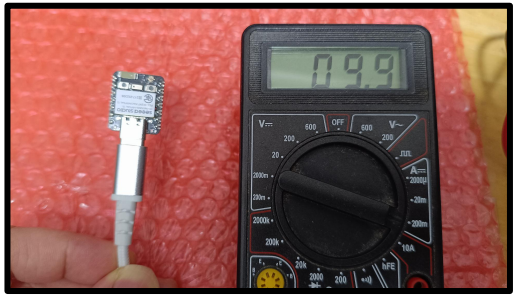
Tomohiro Kaneko

Brother Industries, Ltd.

This presentation is about My Hobby.
(Not work-related!)

Occupation: Hardware Engineer.





Agenda

An Beginner Introduction to Edge AI on Zephyr

- The State of Edge AI on Zephyr

Lightning Talk:
(About 10～15 minutes)

- A Beginner-Friendly Approach
- Hardware That Worked for Me & **Short Demo**
- Summary

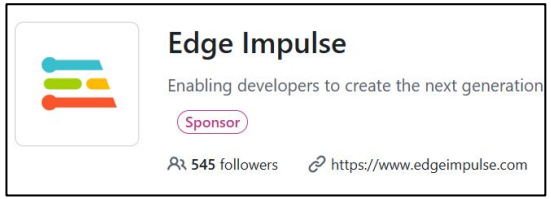
The State of Edge AI on Zephyr

Zephyr already provides support

Major Edge AI frameworks already support for Zephyr.

Edge AI Models

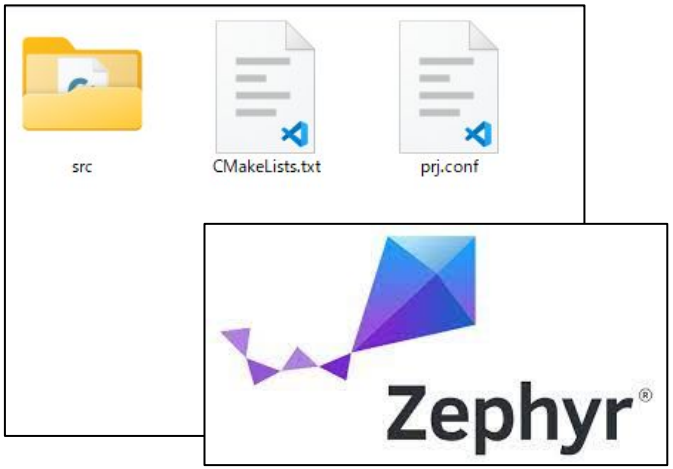
https://github.com/tensorflow/tflite-micro



https://edgeimpulse.com/

We can build together.

Zephyr Project



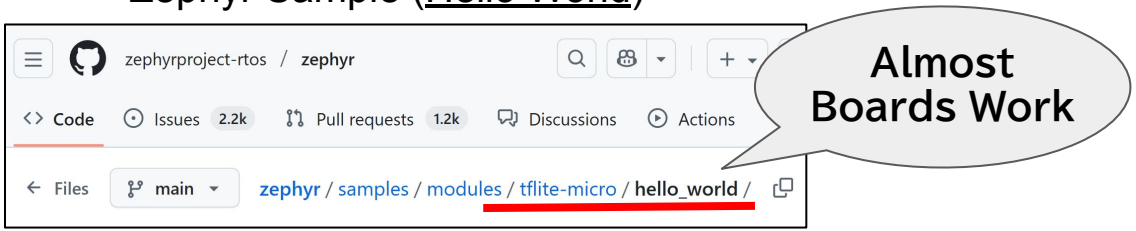
https://www.zephyrproject.org/

■It’s easy to deploy and run Edge AI models directly on Zephyr.

Many official support

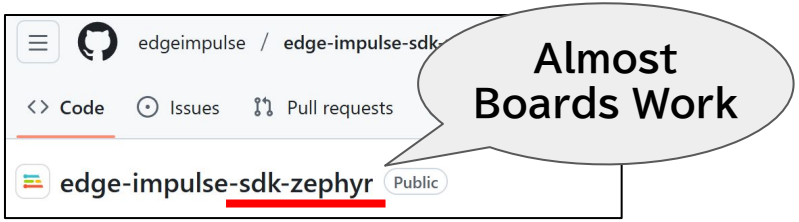
There's a lot of support, including Samples, SDKs, Boards.

・Zephyr Sample (Hello World)



https://github.com/zephyrproject-rtos/zephyr/tree/main/samples/modules/tflite-micro

・Edge Impulse SDK Zephyr



https://github.com/edgeimpulse/edge-impulse-sdk-zephyr

・Edge Impulse Complete Samples with sensors

Temp, Humidity, Accel… sensors implemented

Many official Board support

Example

https://github.com/edgeimpulse/firmware-nordic-thingy91

https://www.nordicsemi.jp/tools/thingy91/

For Beginner (and Me)...

To make it easier to Debug Edge AI on Zephyr...

But I don't have official support board…

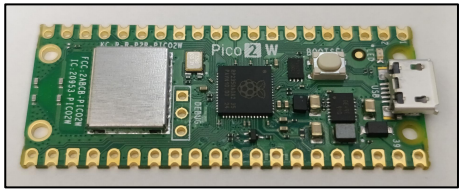
≒$100~$150 ?

Temp, Humidity, Accel… sensors implemented

How I Got Started?

Useful & Low-Cost Boards

Pico2(W)≒$10



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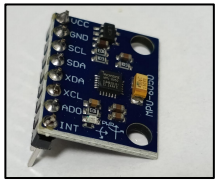


Accel Sensor
≒$3

OR

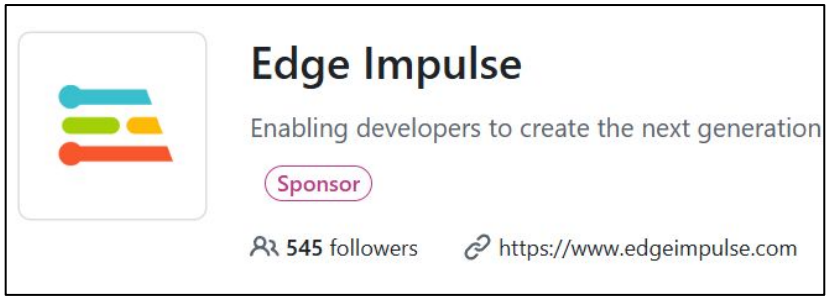
XIAO nRF54L15 Sense ≒$15

Integrated with
・Accel sensor
・Micropone

A Beginner-Friendly Approach

Edge Impulse

A development platform for lightweight AI models.



https://edgeimpulse.com/

Zephyr®

https://www.zephyrproject.org/

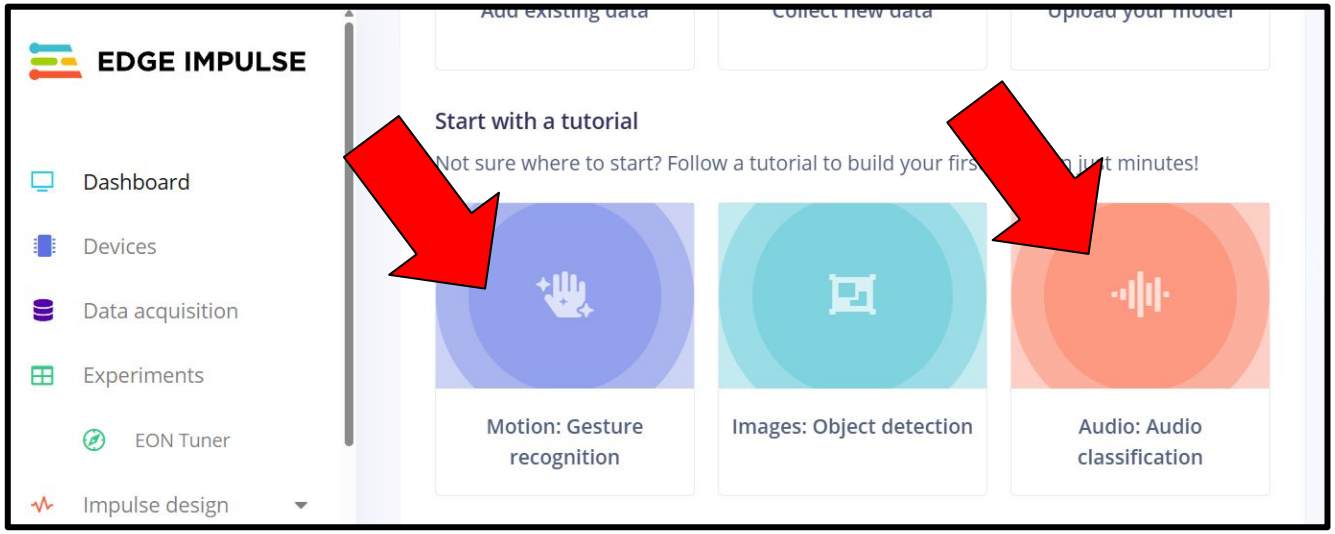
■Overview:

・Easily create AI models (machine learning models) from sensor data.

・Create lightweight models → Integrate them into Zephyr.

What kind of models can you build?

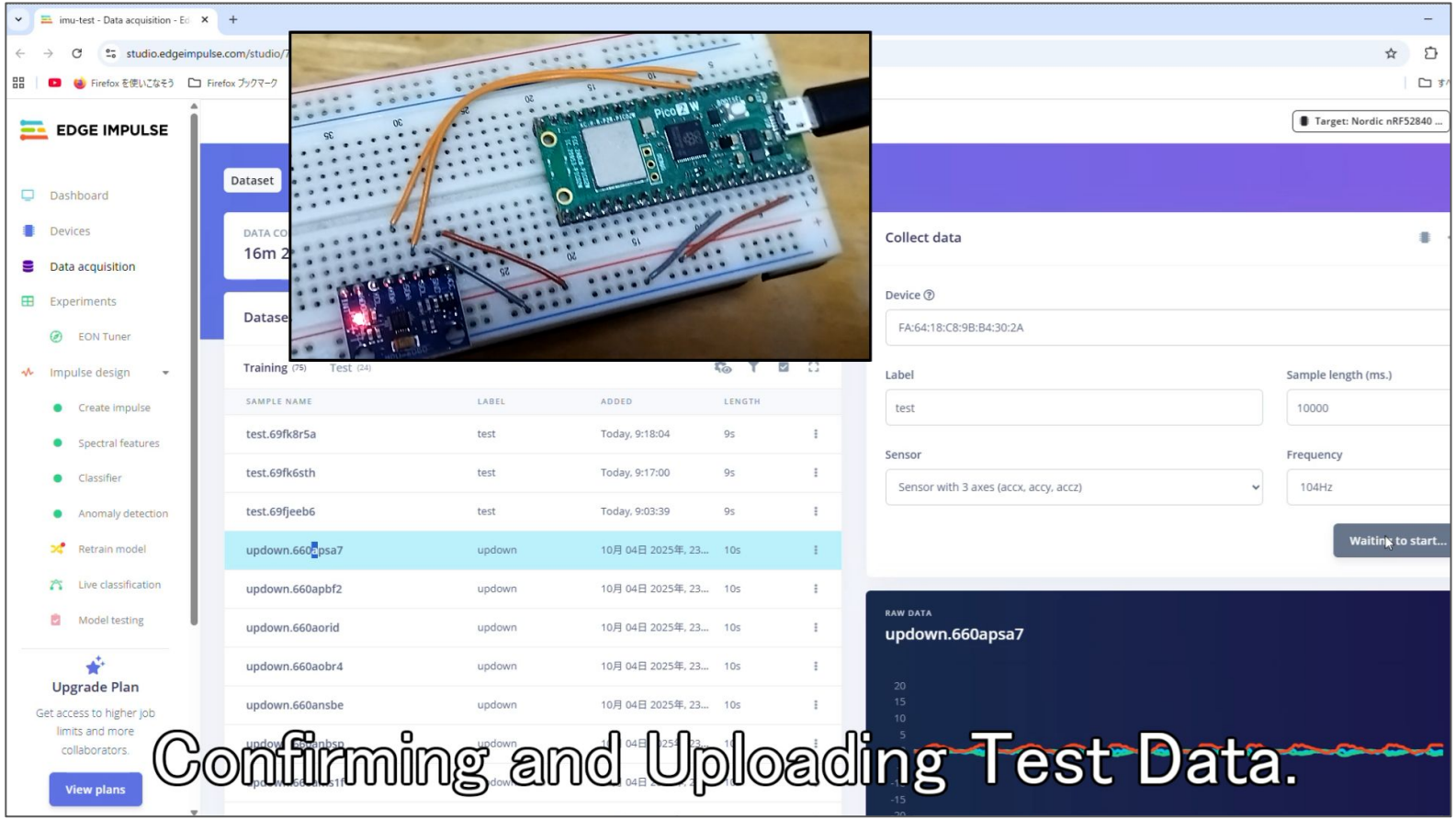
Lightweight AI models for Motion, Images, and Audio…



https://edgeimpulse.com/

■Today, I will introduce ”Motion” and ”Audio” example with useful Board.

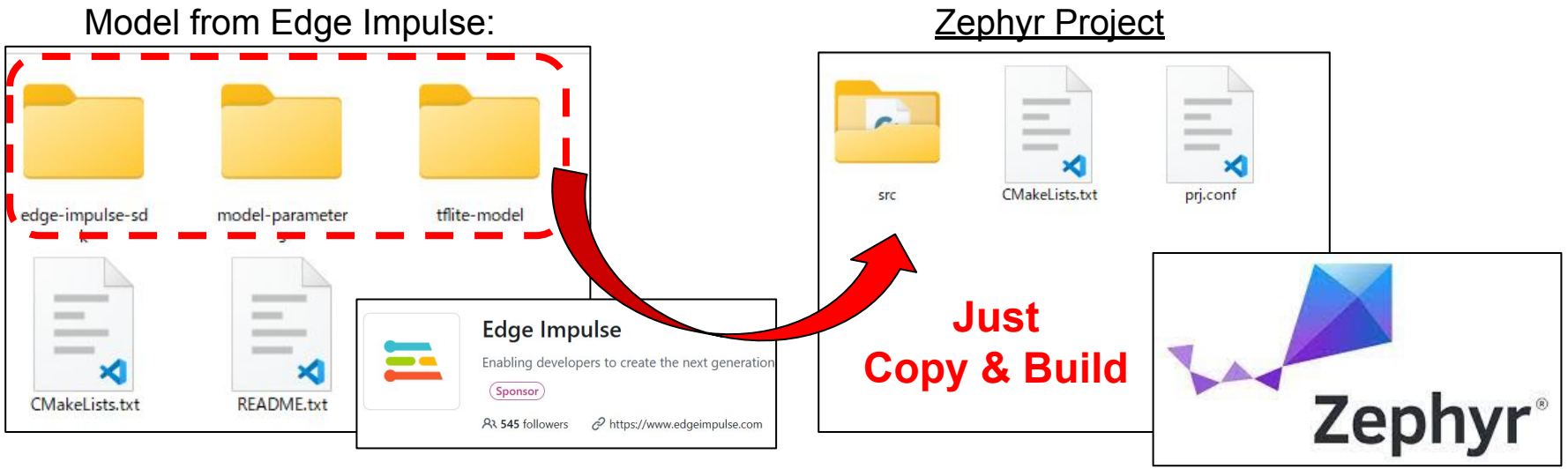
Uploading Demo for Edge Impulse



https://youtu.be/5CdPXB99Jo0

Integrating a Lightweight AI Model

The program and instructions are available on GitHub.



■My Test Overview

・Audio ：Loop of [Save 1 second of Mic data] → [Run inference]

・Motion: Loop of [Save 2 seconds of Accel data] → [Run inference]

Good Thing for Zephyr

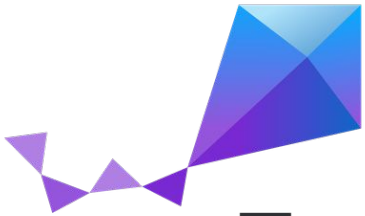
Zephyr & Edge AI fit in small RAM and ROM.

・Build result example (Motion Recognition)

ROM:177kB, RAM:27kB

Match Low-end SoCs/CPUs

```
Memory region         Used Size  Region Size  %age Used
           FLASH:      176816 B         4 MB      4.22%
             RAM:       26640 B       520 KB      5.00%
        IDT_LIST:           0 GB        32 KB      0.00%
Generating files from C:/Users/ioten/zephyrproject/test/
/zephyr/zephyr.elf for board: rpi_pico2
Converted to uf2, output size: 353792, start address: 0x
Wrote 353792 bytes to zephyr.uf2
```



Zephyr®

■Including the AI model, fits into kBytes of RAM and ROM.

Hardware That Worked for Me
&
Short Demo

My Test Example

These were made for hobby, so please use just as a reference.

We can use
Useful & Low-Cost Boards

■GitHub

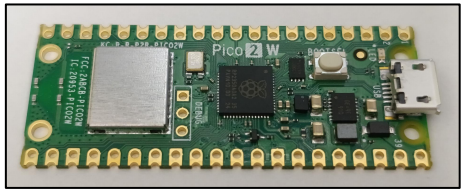
・zephyr-ei-xiao-nrf-demo
XIAO nRF54L15 Sense
https://github.com/iotengineer22/zephyr-ei-xiao-nrf-demo

・pico2-ei-zephyr-demo
Raspberry Pi Pico 2(W) & Sensor Board
https://github.com/iotengineer22/pico2-ei-zephyr-demo

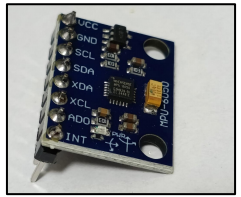
XIAO nRF54L15 Sense ≒$15

Integrated with
・Accel sensor
・Microphone

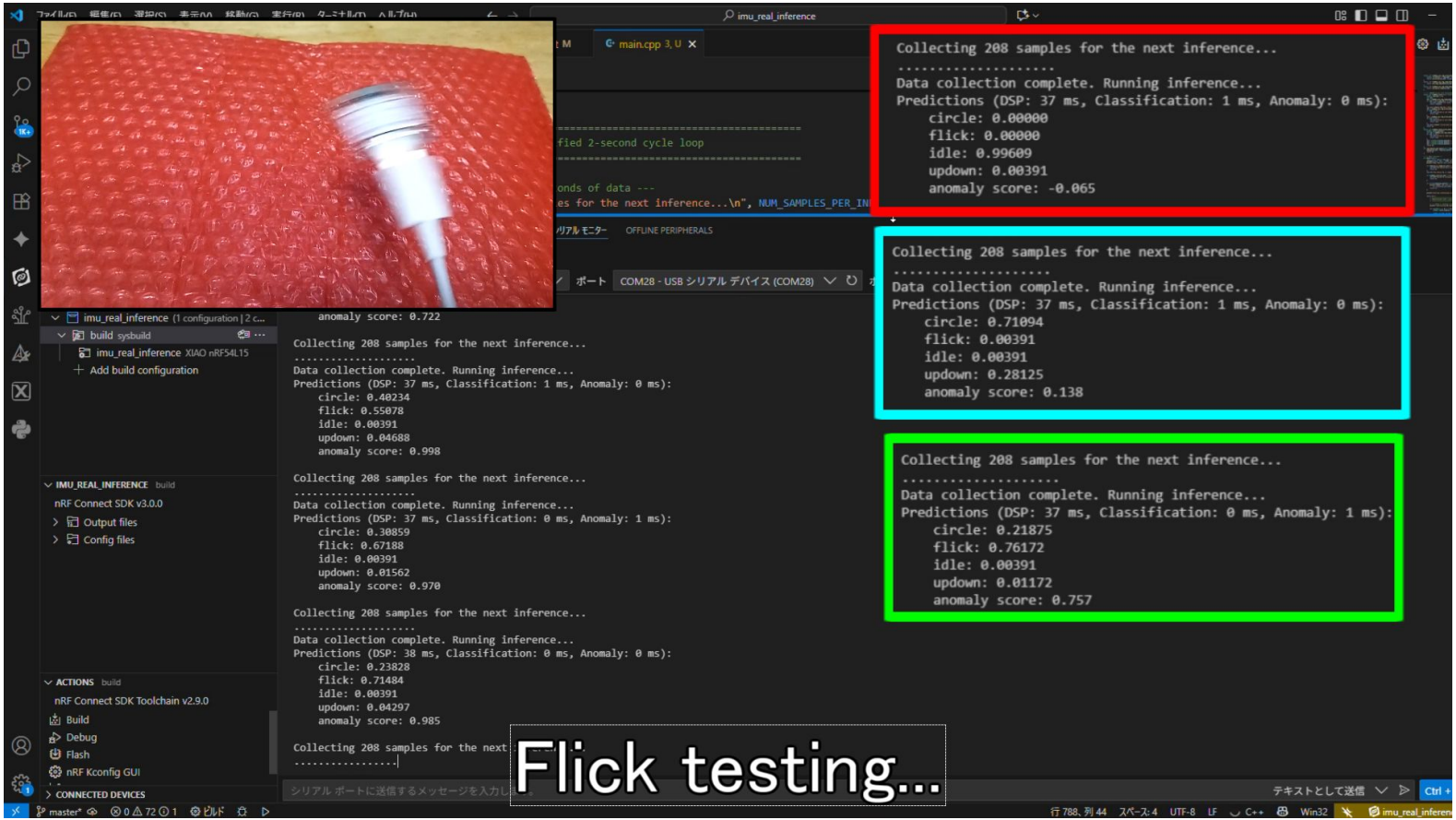
Pico2(W)≒$10



Sensor≒$3



Motion Demo (XIAO nRF54L15 Sense)



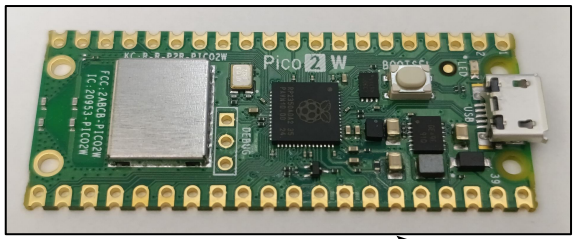
https://youtu.be/FqW0INMxQlg

Motion Demo (Raspberry Pi Pico 2(W))

https://youtu.be/kFZd0z9Mo5U

Motion Recognition Live Demo (Idle, Flick, Updown)

Pico2(W)≒$10



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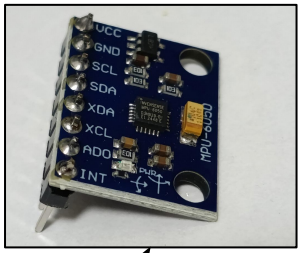
Accel Sensor
(MPU-6050)≒$3



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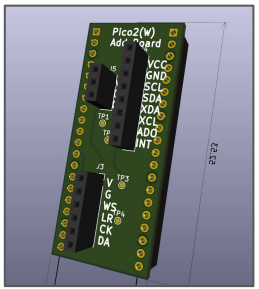
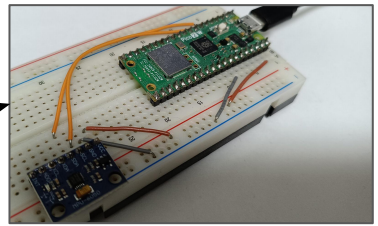
Pico2(W) Add Board≒$5



■PCB_DATA(GitHub)
https://github.com/iotengineer22/pico2-ei-zephyr-demo/tree/main/pcb

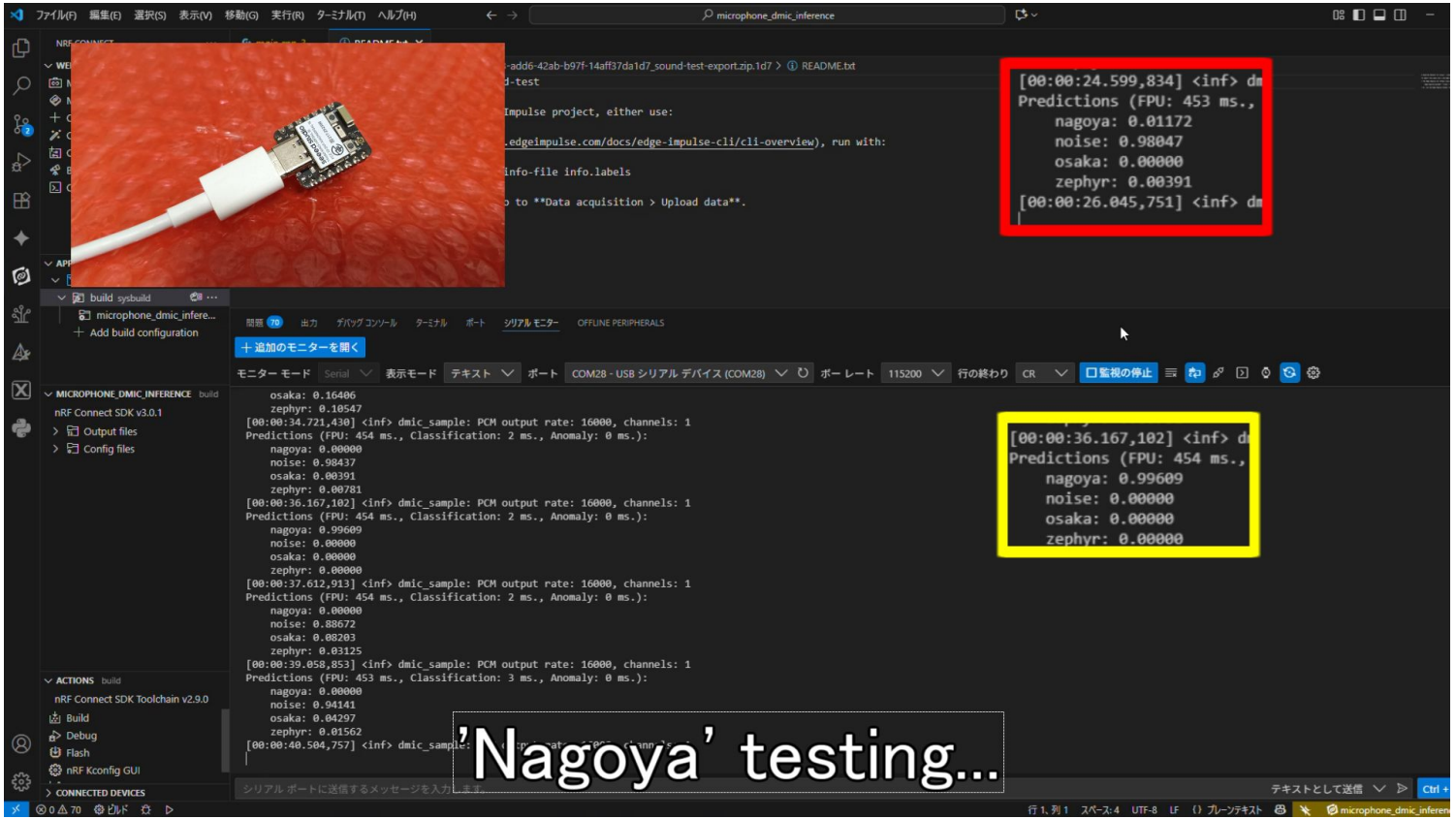
(Or Bread Board with Wire≒$10)



Pico2(W)	Sensor (MPU-6050)
39 (VSYS)	1 (VCC)
38 (GND)	2 (GND)
7 (I2C0 SCL)	3 (SCL)
6 (I2C0 SDA)	4 (SDA)

*Anyone can buy from Online marketplaces

Audio Demo (XIAO nRF54L15 Sense)



https://youtu.be/IbxTMiPwFTU

Audio Recognition Live Demo (Tokyo, Japan, Zephyr)

XIAO nRF54L15 Sense ≒$15

Integrated with
- **Accel sensor**
- **Microphone**

*Anyone can buy from Online marketplaces

Summary

Summary

I was able to debug Edge AI on Zephyr with useful boards ！

・XIAO nRF54L15 Sense & Pico 2(W)
match for debugging Edge AI on Zephyr.

・Lightweight Edge AI model fit Zephyr.
(Including the AI model, fits into kBytes of RAM/ROM.)

・If you’re interested, please debug it.
(Zephyr already provides many support for Edge AI.)

In Closing

Thank you for your attention.

Q&A Example:1

Question	Answer
Can we test this on other boards?	**Yes, likely.** Edge Impulse supports many ICs (e.g., Arduino, NXP, Renesas, ST). https://docs.edgeimpulse.com/hardware
Is Edge Impulse free to use?	**Yes.** Individuals can use the service for free with some limitations, which is sufficient for this demo level. https://edgeimpulse.com/pricing
How long did the training take?	Very short time—**about 1 minute** for both audio and motion data.
Which deployment mode did you use in Edge Impulse?	We deployed using the **C++ Library**. (They recently added Zephyr support, which might be worth testing.) https://www.edgeimpulse.com/blog/announcing-the-edge-impulse-zephyr-module/
Can we run the Audio demo on Raspberry Pi Pico 2?	**Maybe.** It should be possible by reading I2S/PDM data using PIO mode. (Scheduled for testing during the winter break.)
Is a Video(Image) demo possible?	**Maybe.** We believe it can be implemented even on low-spec SoCs using an SPI camera. (Scheduled for testing during the winter break.)
Why is the model so lightweight?	The model matrices are hard-coded into the `.h` files. This trades off generality and flexibility for **extremely light weight**.

Q&A Example:2

Question	Answer
What was the most difficult point?	Setting up the configuration files (CMakeLists and prj.conf) for Zephyr. Since there were many examples for Arduino + Edge Impulse, I adapted those. Also, managing naming conflicts, especially in the USB serial area, between the recent Edge Impulse SDK and Zephyr device names.
Why did you choose Edge Impulse?	I first used it for the Hardware contest. I found the platform interesting, so I have continued testing and debugging with it. (I will talk about this further in the session starting at 16:40.)