

SEPTEMBER 5 | 5:00 PM (JST) | ONLINE

EDGE AI LAB WITH MICROCONTROLLERS

FROM DATA COLLECTION
TO DEPLOYMENT



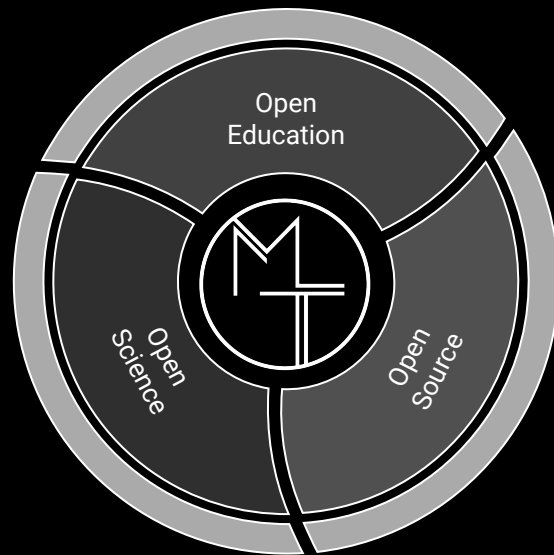
MACHINE
LEARNING
TOKYO

MLT

Machine Learning Tokyo (MLT) is an award-winning nonprofit organization 一般社団法人 based in Japan.

MLT is dedicated to democratizing Machine Learning through open education, open source and open science.

We support an international research- and engineering community of more than 9,500 members.

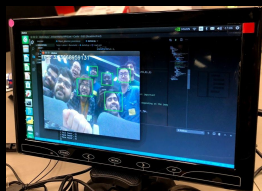
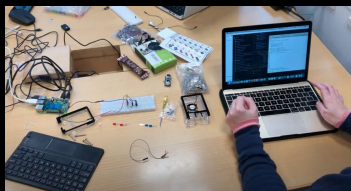


MLT EdgeAI Lab










MLT Agritech team visiting
Hacker Farm in Chiba



EdgeAI Lab Hardware
Working Session

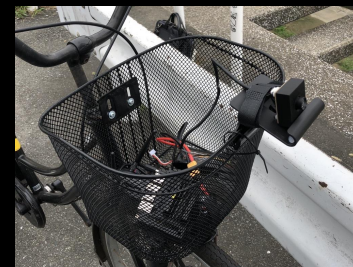


Signate 3rd AI Edge

Final Rank	Teannname / Username	Private
1st	 RailStar737A	 0.62610
2nd	 IRAFM-AI	 0.61198
3rd	 MLT	    0.60545



Jetson Nano deployment on bicycle



Join #edge_ai_lab on MLT Slack
<https://machinelearningtokyo.slack.com>

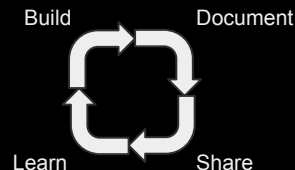


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Introduction of Series

Goal is to help you build your Edge AI application by end of the series

- Build / Document / Share / Learn



Overview of entire Series

- Session #1 : Overview of Edge AI Applications
- Session #2 : Motion Based Application using IMU
- **Session #3 : Audio Based Application using Microphone**
- Session #4 : Wrap-up session

Today's Agenda (Session #3)

- 05:00 - 05:15: Introduction
- 05:15 - 05:45: Presentation, Walkthrough, and Demo of Audio Based Edge Application
- 05:45 - 06:15: Brainstorming
- 06:15 - 06:30: Sharing / QA

Join **#edge_ai_lab** on MLT Slack

<https://machinelearningtokyo.slack.com>



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Introduction of Organizers

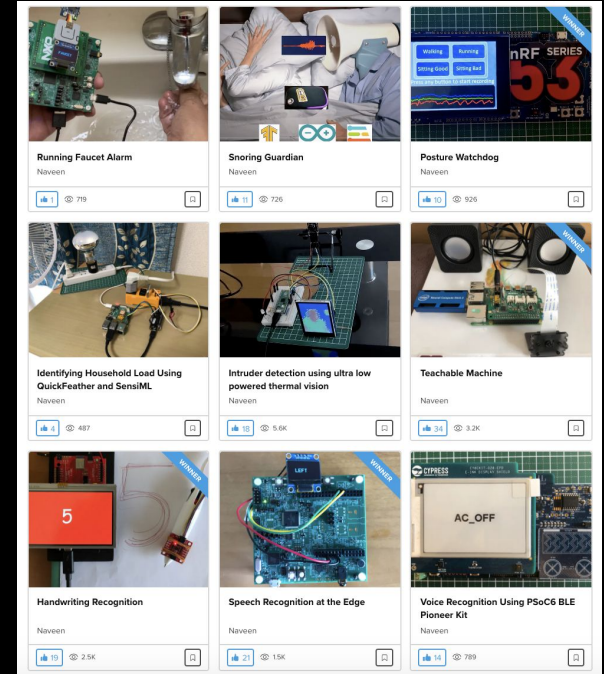
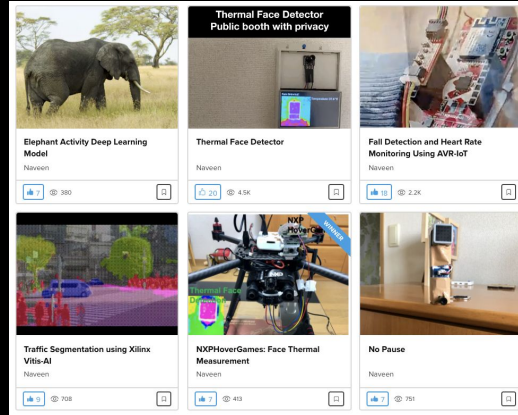


Naveen Kumar

- Watching movies
- Nature photography
- Playing with microcontrollers



My Edge AI projects at
hackster.io/naveenbskumar

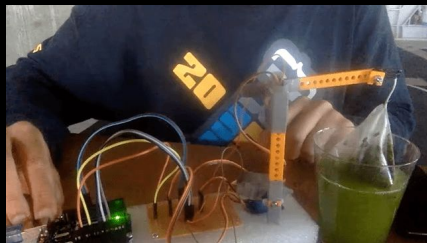


Introduction of Organizers

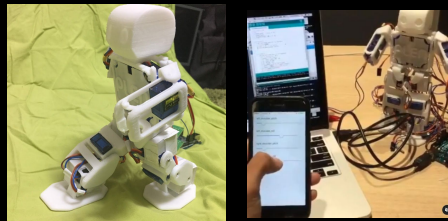


Yoovraj Shinde

- Love Eating Food
- Playing with robots

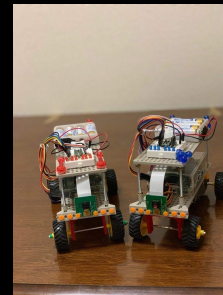


Past Projects



Personal Plen Robot

- 3d printed parts
- Arduino
- iOS App

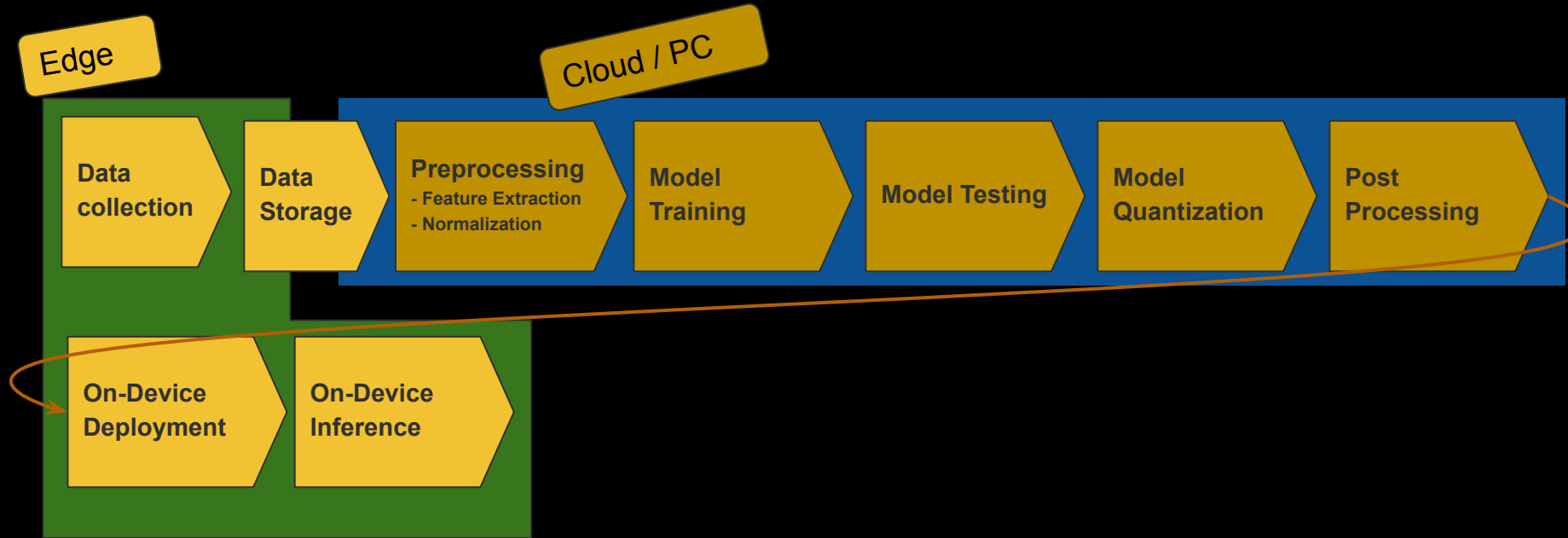


Robot Car for Kids

- Tamiya Kits
- Raspberry Pi
- Scratch

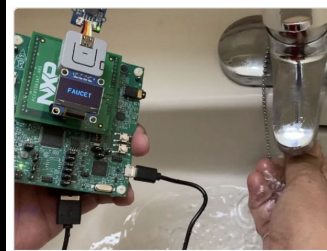


Blocks of Edge AI Pipeline



Example Edge AI Applications using Microphone

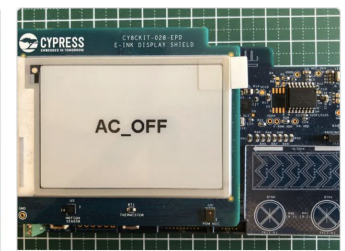
- Detect Audio Events
- Keyword Recognition
- Detect Respiratory Sound



Running Faucet Alarm

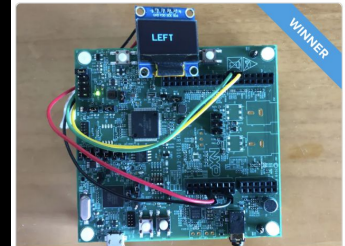


Snoring Guardian



Voice Recognition Using PSoC6 BLE Pioneer Kit

hackster.io/naveenbskumar

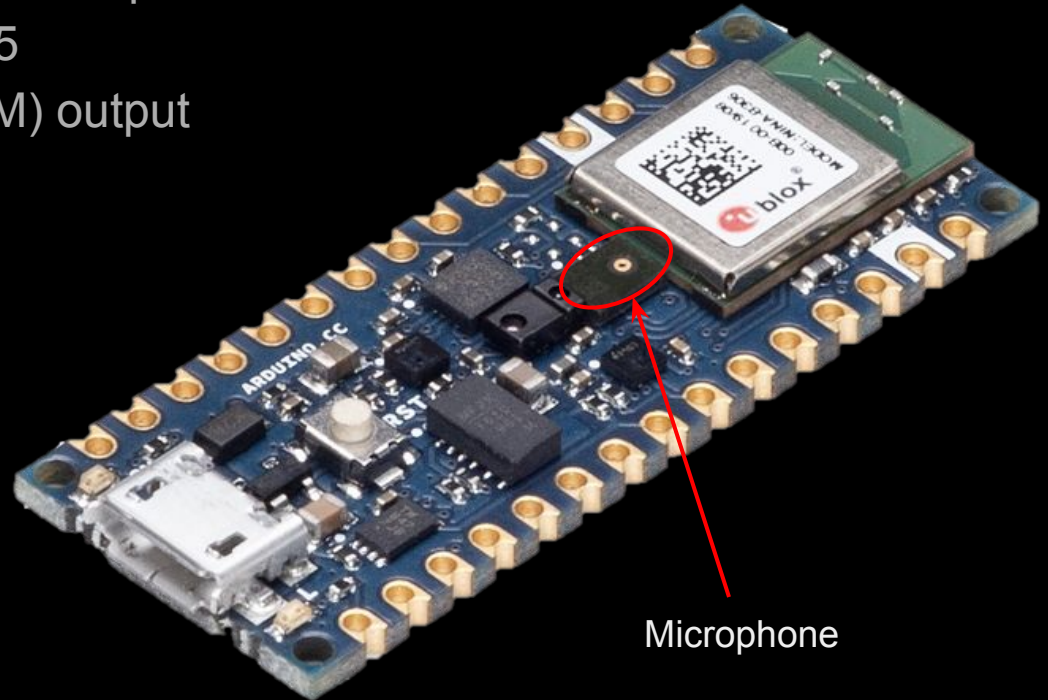


Speech Recognition at the Edge



Arduino Nano 33 BLE Sense on-board Microphone

- Omnidirectional, digital MEMS microphone
- STMicroelectronics MP34DT05
- Pulse-density modulation (PDM) output



Microphone



Project: Snoring Sound Detection

- Snoring is caused by the rattling and vibration of tissues near the airway in the back of the throat.
- The aim of this project is to detect the snoring sound during sleep.
- Understanding data collection process and Digital Signal Processing to extract features
- Coding is not required for simple working demo but advanced users may customize the source code
- Rapid prototyping using Edge Impulse Studio

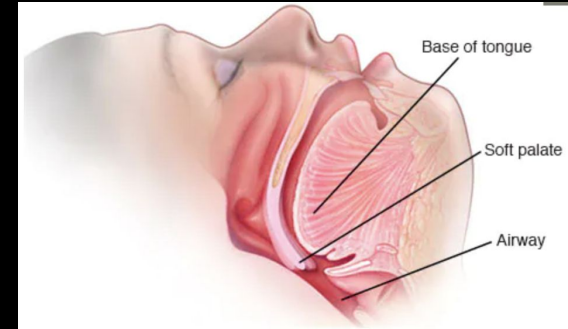


Image credit: Mayo Foundation for Medical Education and Research



What is Pulse Density Modulation (PDM)?

- From Sound Pressure to PDM, represent an analog signal with a binary signal
- PDM is the '3rd' kind of microphone interface we can integrate with microcontroller, apart from analog or I2S.
- PDM is a little like 1-bit PWM.

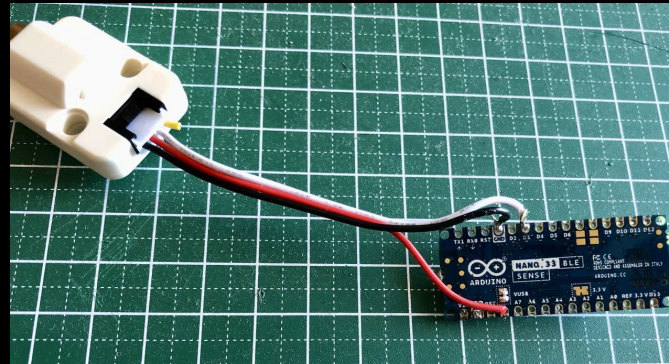
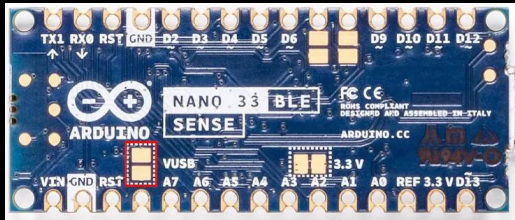
A single period of the sine function, sampled 100 times and represented as a PDM bitstream:



Image credit: Wikipedia

Software/Hardware Setup

- It is assumed that Arduino IDE and Arduino Core for Nano 33 BLE Sense are already installed.
- A vibration motor is used as an output and it starts vibrating if snoring sound is detected.
- Requires basic soldering skills
- To power it using 5V pin we need to make a solder bridge on the two pads marked as VUSB.



Data Collection

- Download Snoring and other nature sounds which may occur during night from Audioset, a large-scale dataset of manually annotated audio events.
- AudioSet consists of an expanding ontology of 632 audio event classes and a collection of human-labeled 10-second sound clips drawn from YouTube videos.
- The audio are extracted from the YouTube videos of the select events and converted into Waveform Audio file format (wav) with 16-bit depth mono channel at 16KHz sample rate.

Snoring	Dog
Vehicle	Sneeze
Toilet flush	Cough
Rain	Sniff
Wind	Walk, footsteps
Television	Humming
Radio	Squeak
Silence	Traffic noise
Insect	roadway noise
Tick-tock	Human Voice
Baby cry, infant cry	Chirp, tweet
	Music

{ ||| } AudioSet



<http://research.google.com/audioset>



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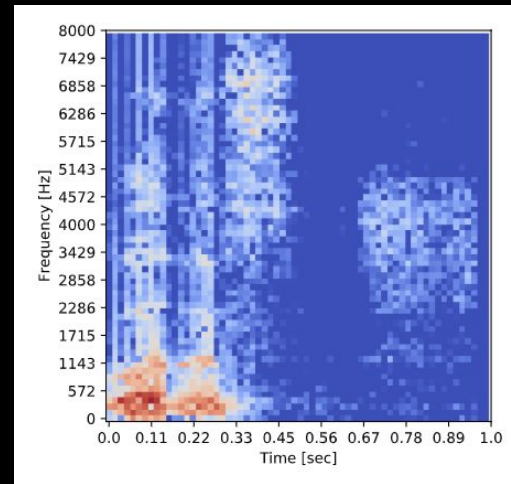
Data Storage

- Register a free account at edgeimpulse.com and create a new project.
- Install Edge Impulse CLI on your local computer.
<https://docs.edgeimpulse.com/docs/cli-installation>
- Upload all wav files to Edge Impulse Studio using the command line:
 - ◆ `edge-impulse-uploader --clean`
 - ◆ `edge-impulse-uploader --label snoring --category split snoring/ *.wav`
- The datasets are automatically split into training and testing sets by using command above.



Feature extraction using Spectrogram

- Spectrogram is a visual representation of the spectrum of frequencies of a non-periodic signal
- Performs well on audio data for non-voice recognition
- Extracts time and frequency features from a signal
 - ◆ Divide the window in multiple overlapping frames
 - ◆ Each time frame is then divided in frequency bins using an FFT (Fast Fourier Transform)
 - ◆ Compute its power spectrum



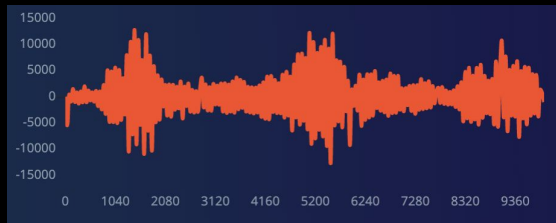
Spectrogram of a snoring sound



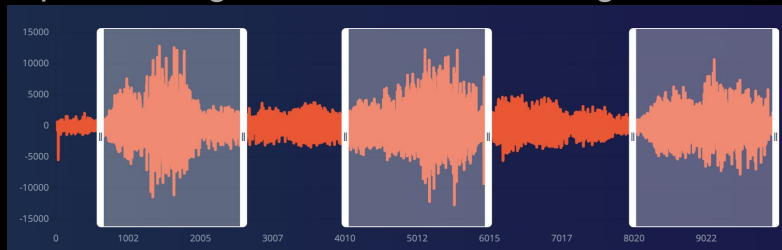
Digital Signal Processing

Audio raw data (16000 samples/sec)

[61, 204, 303, 198, 98, 178, 259, 307, 371, 279, -6, -208, -253, -320, -348, -251, -130, -42, 43, 10, -169, -277, -236, -251, -358, -261, -65, -63, -134, -151, -321, -577, -551, -312, -178, -75, -6, -186, -334, -186, -67, -157, -158, -22, 105, 207, 248, 126, -145, -320, -223, -14, 43, 30, 63, 30, -78, -164, -220, -175, -44, 2, ...]



Split into segments to remove background noise

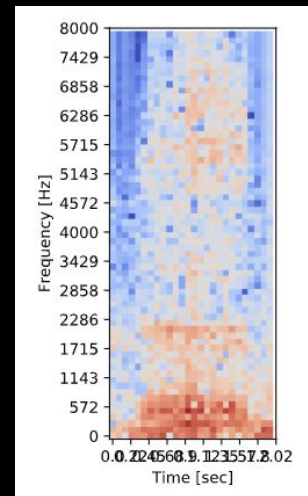


Signal to Spectrogram



2000 ms Window size
1000 ms Window Increase

FFT



Demo: Data Collection/DSP/Training

Demo: On-Device Inferencing

All code and material of the session

→ Walkthrough of the Arduino Inferencing sketch



```
tflite_micro_snoring_detection | Arduino 1.8.14

// If your target is limited in memory remove this macro to save 18K RAM
#define EIDSP_QUANTIZE_FILTERBANK 0

/**
 * Define the number of slices per model window. E.g. a model window of 1000 ms
 * with slices per model window set to 4. Results in a slice size of 250 ms.
 * For more info: https://docs.edgeimpulse.com/docs/continuous-audio-sampling
 */
#define EI_CLASSIFIER_SLICES_PER_MODEL_WINDOW 3

/* Includes */
#include <PDM.h>
#include <Scheduler.h>
#include <RingBuf.h>
#include <snore_detection_inferencing.h>

/** Audio buffers, pointers and selectors */
typedef struct {
    signed short *buffers[2];
    unsigned char buf_select;
    unsigned char buf_ready;
}
```

→ Github repository for the project source code and documentation

◆ <https://github.com/Machine-Learning-Tokyo/edgeai-lab-microcontroller-series>



Brainstorming Session

WhiteBoards for Brainstorming

Project Push Up Classification (and Counting)

<https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629005216375/3e7cd6437df6ba9b5392b66fa2c490ab27c36a34?sender=u95ce3da66ee17f1954ba5414>

Project Cat Activity Detection

<https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629005197838/c71484add603e0de284da41e7329682aafea500?sender=u95ce3da66ee17f1954ba5414>

Audio / Motion Based Application

- **Audio :**

<https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629005225173/1d56c2b023c5fde1dfef6ee8a8a978f66287fa38?sender=u95ce3da66ee17f1954ba5414>

- **Motion :**

<https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629005207313/cfdd36833f34ff6db2cd9aaa5c2b76043c947933?sender=u95ce3da66ee17f1954ba5414>



Next Session

- Session #4 : Wrap up session September 19 (5:00 PM - 6:30 PM JST)
 - ◆ 2 weeks for all of us to create exciting projects
 - ◆ Sharing of projects you have worked on during this entire series
 - ◆ Will be announced soon on MLT Meetup page.



END



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