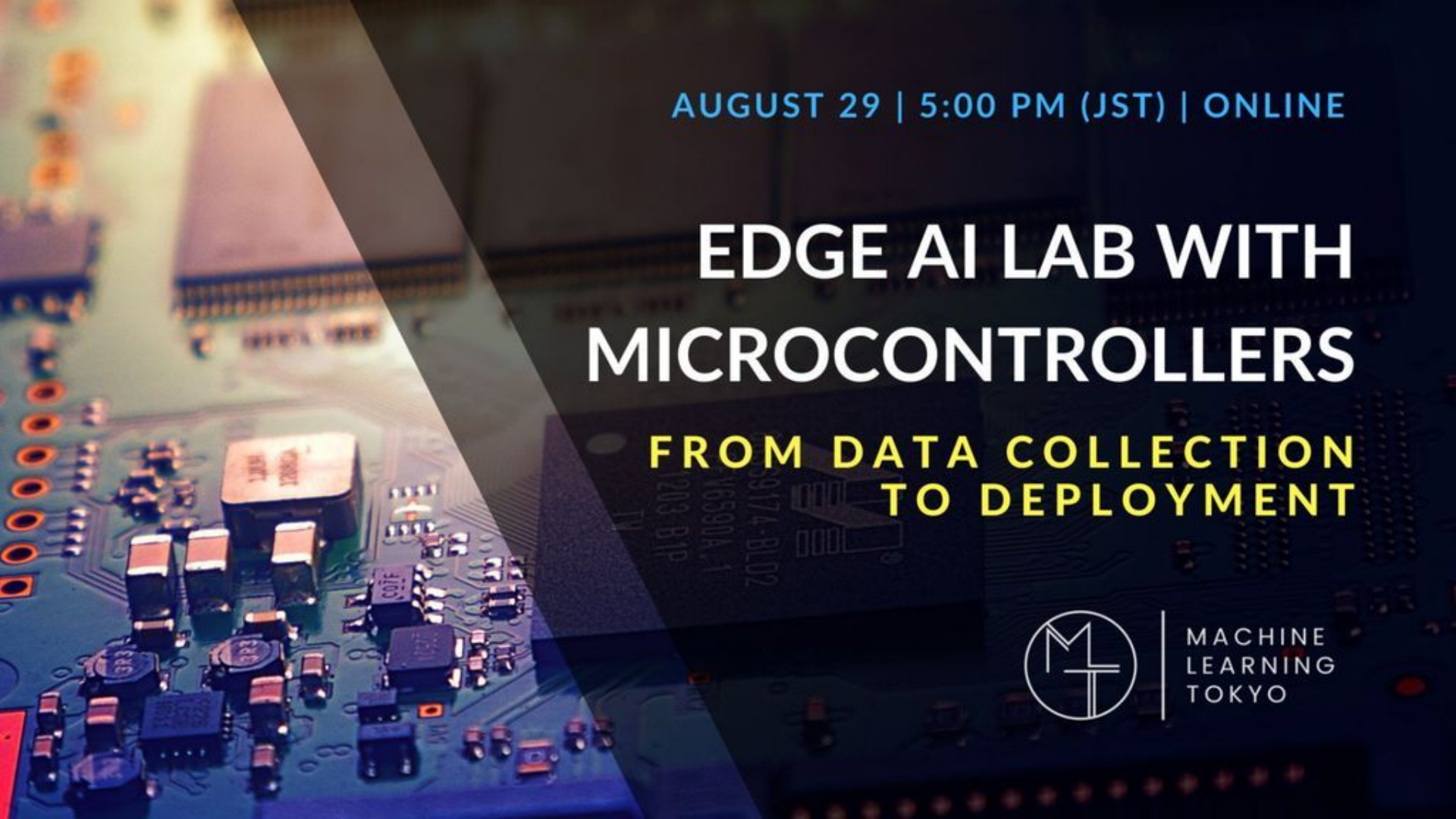
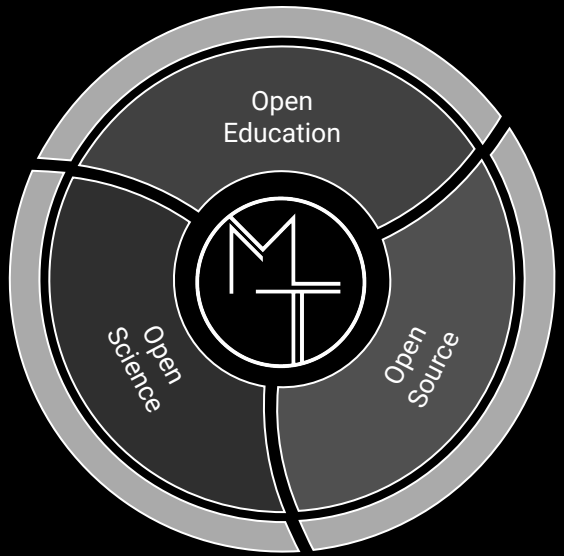

AUGUST 29 | 5:00 PM (JST) | ONLINE
EDGE AI LAB WITH MICROCONTROLLERS
FROM DATA COLLECTION TO DEPLOYMENT
MACHINE LEARNING TOKYO

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.



MACHINE
LEARNING
TOKYO

Ref : https://machinelearningtokyo.com

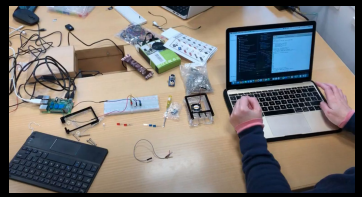
MLT EdgeAI Lab

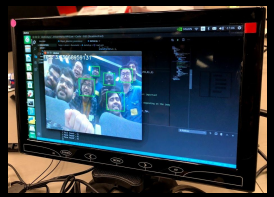
MLT Agritech team visiting Hacker Farm in Chiba

Signate 3rd AI Edge

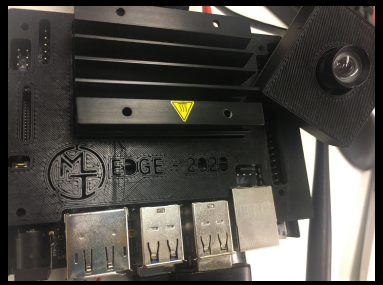
Final Rank	Teamname / Username	Private
1st	RailStar737A	0.62610
2nd	IRAFM-AI	0.61198
3rd	MLT	0.60545

EdgeAI Lab Hardware Working Session





Jetson Nano deployment on bicycle



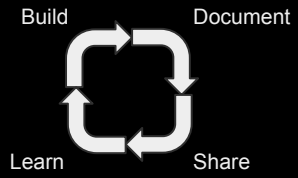
Join **#edge_ai_lab** on MLT Slack
https://machinelearningtokyo.slack.com

MACHINE LEARNING TOKYO

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 #2)

➔ 05:00 - 05:15: Introduction

➔ 05:15 - 05:45: Presentation, Walkthrough, and Demo of Motion 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

MACHINE LEARNING TOKYO

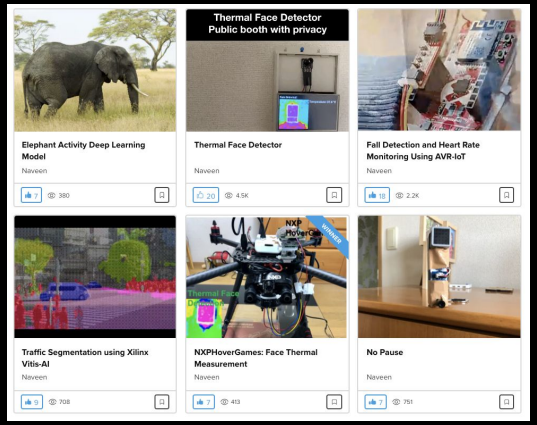
Introduction of Organizers

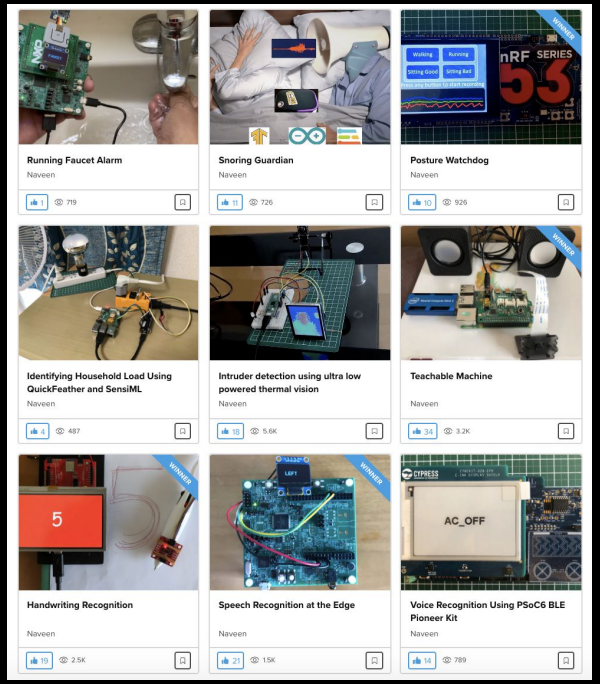
Naveen Kumar

- Watching movies
- Nature photography
- Playing with microcontrollers

@knaveen

My Edge AI projects at
hackster.io/naveenbskumar





MACHINE
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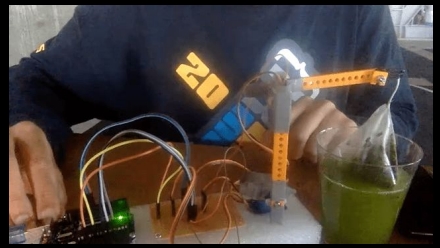
TOKYO

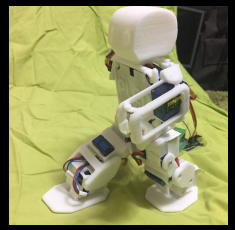
Introduction of Organizers

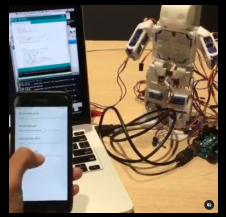
Yoovraj Shinde

- Love Eating Food
- Playing with robots



Past Projects





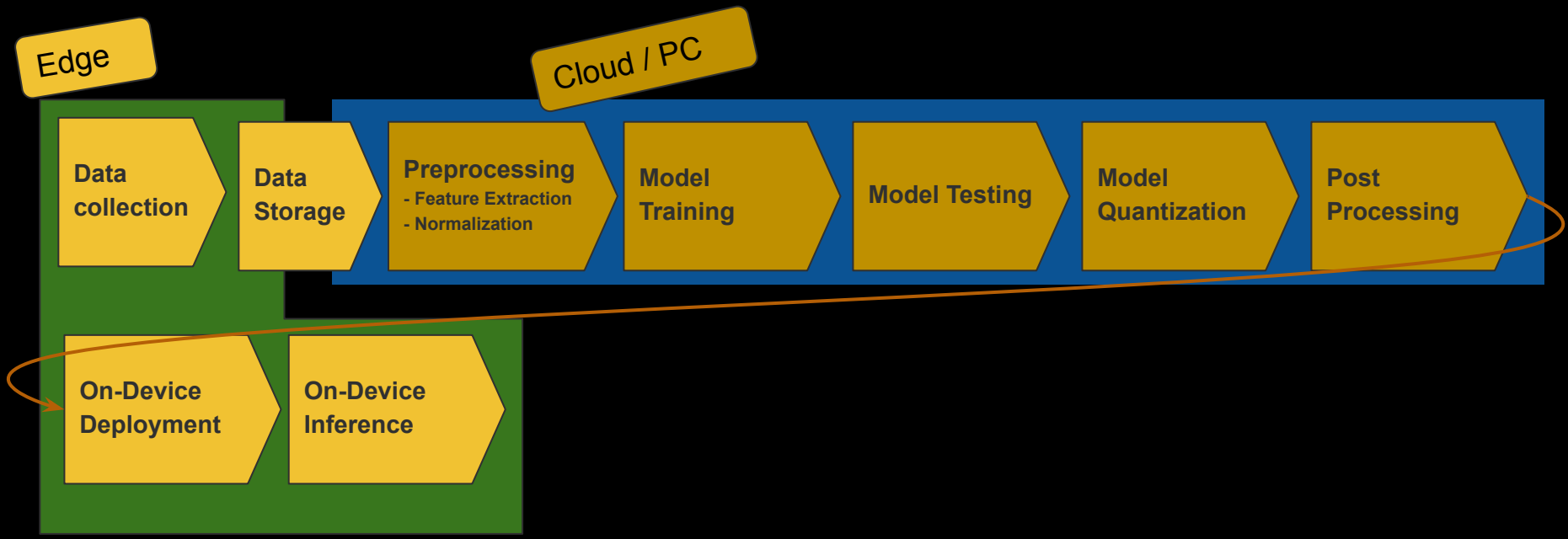
Personal Plen Robot

- 3d printed parts
- Arduino
- iOS App

Robot Car for Kids

- Tamiya Kits
- Raspberry Pi
- Scratch

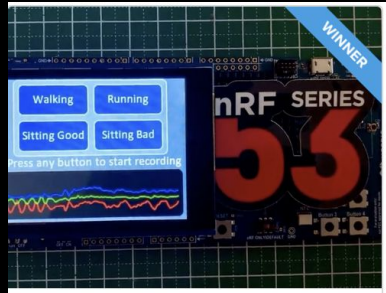
Blocks of Edge AI Pipeline



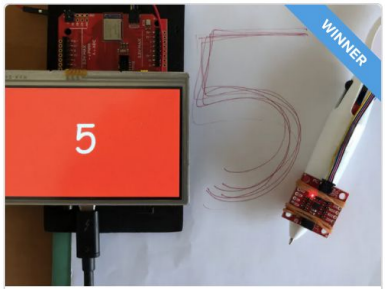
MACHINE LEARNING TOKYO

Example Edge AI Applications using IMU

- Posture recognition
  - Accelerometer
- Handwriting recognition
  - Accelerometer/Gyroscope
- Activity recognition
  - Accelerometer/Gyroscope
- Fall detection
  - Accelerometer



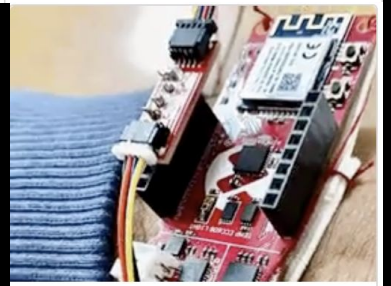
Posture Watchdog



Handwriting Recognition

Elephant Activity Deep Learning Model

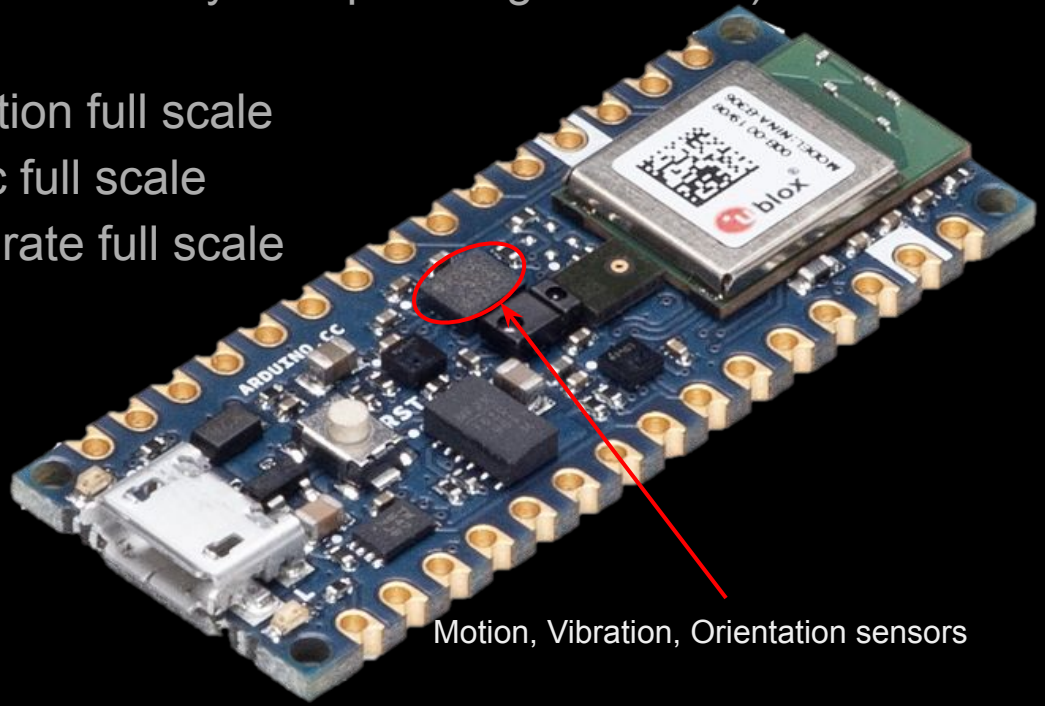
hackster.io/naveenbskumar



Fall Detection and Heart Rate Monitoring Using AVR-IoT

IMU of Arduino Nano 33 BLE Sense

- ➔ 9 axis inertial sensor (Accelerometer / Gyroscope / Magnetometer)
- ➔ LSM9DS1
- ➔ ±2/±4/±8/±16 g linear acceleration full scale
- ➔ ±4/±8/±12/±16 gauss magnetic full scale
- ➔ ±245/±500/±2000 dps angular rate full scale
- ➔ I2C serial interface



MACHINE LEARNING TOKYO

What is an Accelerometer?

- ➔ Acceleration is the rate of change of the velocity of an object in m/s^2 or in G-forces (g) units
- ➔ Accelerometers are electromechanical devices that measure linear acceleration in X, Y or Z axis.
- ➔ They sense either static (gravity) or dynamic (vibrations and movement) forces of acceleration.

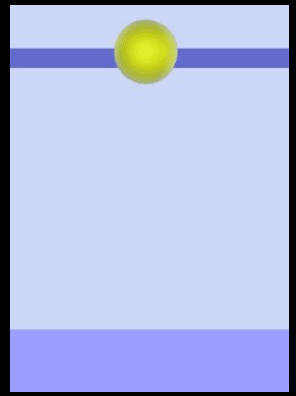


Image Credit: Wikipedia

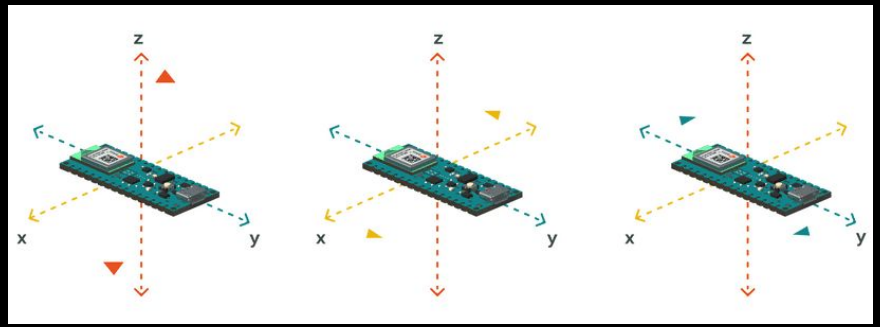


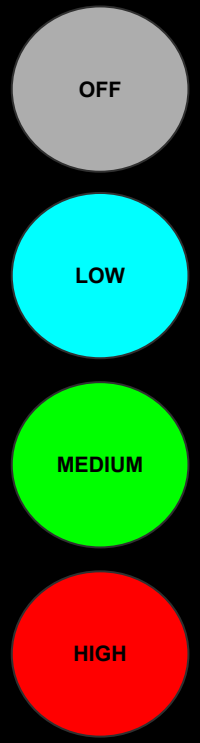
Image Credit: arduino.cc

Edge AI industrial use case: Vibration Analysis

- ➔ Vibration refers to the movement or mechanical shaking around the equilibrium position of a machine or part.
- ➔ Vibrations are usually periodic.
- ➔ Vibration analysis allows us to evaluate the condition of equipment (e.g., motors) and avoid failures (predictive maintenance).
- ➔ Vibration analysis can also be used in structural health monitoring (eg: Bridges, Pipes, Turbine Blades)
- ➔ There are two types of vibration of an object: free vibration (tuning fork) and forced vibration (washing machine).

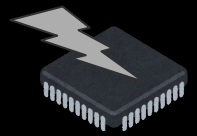
Project: Fan State Detection using Vibration

- ➔ The aim of this project is to detect the speed state of fan by the vibrations created by fan motor.
- ➔ Understanding data collection process and Digital Signal Processing to extract features
- ➔ A simple neural network model can distinguish the states
- ➔ Coding is not required for simple working demo but advanced users may customize the source code
- ➔ Rapid prototyping using Edge Impulse Studio



Mounting the device on the fan

- ➔ Use a rubber band to secure (not too tight) the Arduino Nano 33 BLE Sense on the rear part of the stand fan near the motor.
- ➔ We can keep it in any orientation but horizontally is more convenient.
- ➔ Keep the USB cable plugged in to avoid disorientation.
- ➔ Don't pet your cat while handling or about to handle your microcontroller board (ESD safety).



MACHINE LEARNING TOKYO

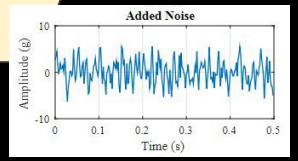
Data collection

- ➔ Create 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
- ➔ Download the latest Edge Impulse firmware, and unzip the file
  https://cdn.edgeimpulse.com/firmware/arduino-nano-33-ble-sense.zip
- ➔ Connect Arduino Nano 33 BLE Sense to your computer using USB cable
- ➔ Open the flash script for your OS (flash_windows.bat, flash_mac.command or flash_linux.sh) to flash the firmware
- ➔ Reset the board
- ➔ Run **edge-impulse-daemon** at command line
- ➔ Go to the Data Acquisition page at Edge Impulse Studio and record new data

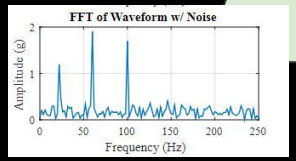
Digital Signal Processing

Scaling → Normalization → High-pass Filter → Fast Fourier Transform

Raw Data (Time Domain)



Processed Data (Frequency Domain)



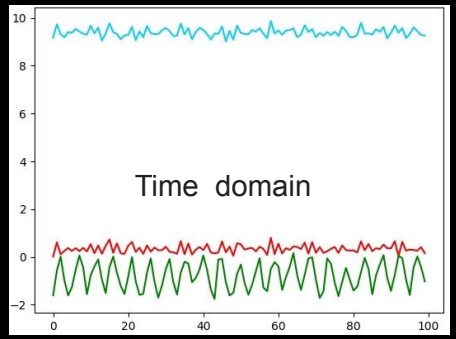
MACHINE LEARNING TOKYO

Ref: https://www.designworldonline.com/the-ultimate-guide-to-vibration-analysis/

Digital Signal Processing

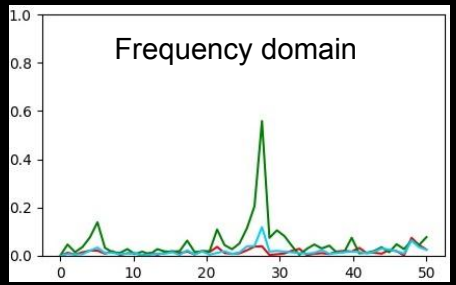
3-axis Accelerometer raw data (100 samples/sec)

```
[[ 1.5600e-02 -1.6077e+00  9.1650]
 [ 6.1530e-01 -5.6740e-01  9.7300]
 [ 1.1010e-01  1.5600e-02  9.3242]
 [ 2.5740e-01 -9.7800e-01  9.1889]
 [ 3.7590e-01 -1.6101e+00  9.4080]
 [ 2.5140e-01 -1.2605e+00  9.3745]
 [ 3.6990e-01 -5.3750e-01  9.5385]
 [ 2.4420e-01  5.8700e-02  9.4344]
 [ 3.8310e-01 -4.3340e-01  9.3374]
 …]
```

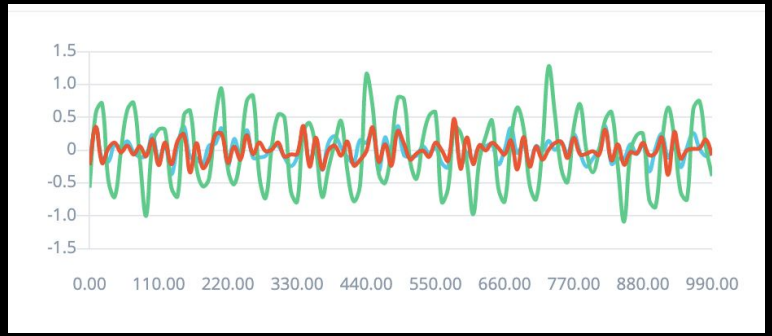


Features Extraction using Spectral Analysis

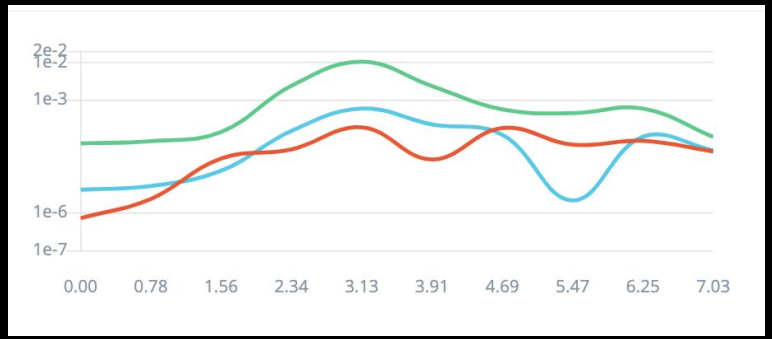
- ➔ Root Mean Square
- ➔ Peak Height
- ➔ Peak Frequency
- ➔ Spectral Power



Normalize by mean subtraction and apply high pass filter



Power spectrum using FFT



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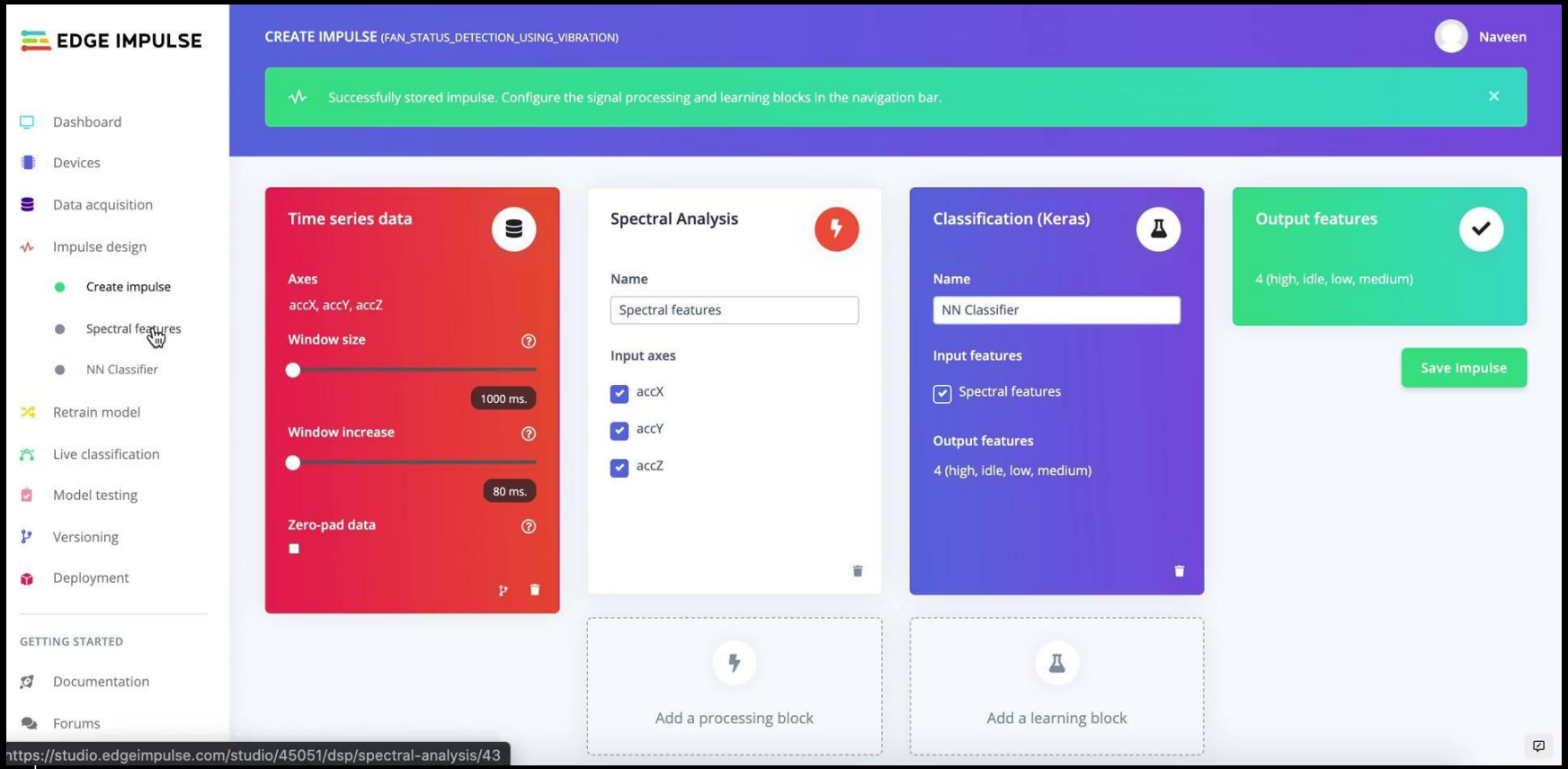
Demo: Data Collection/DSP/Training



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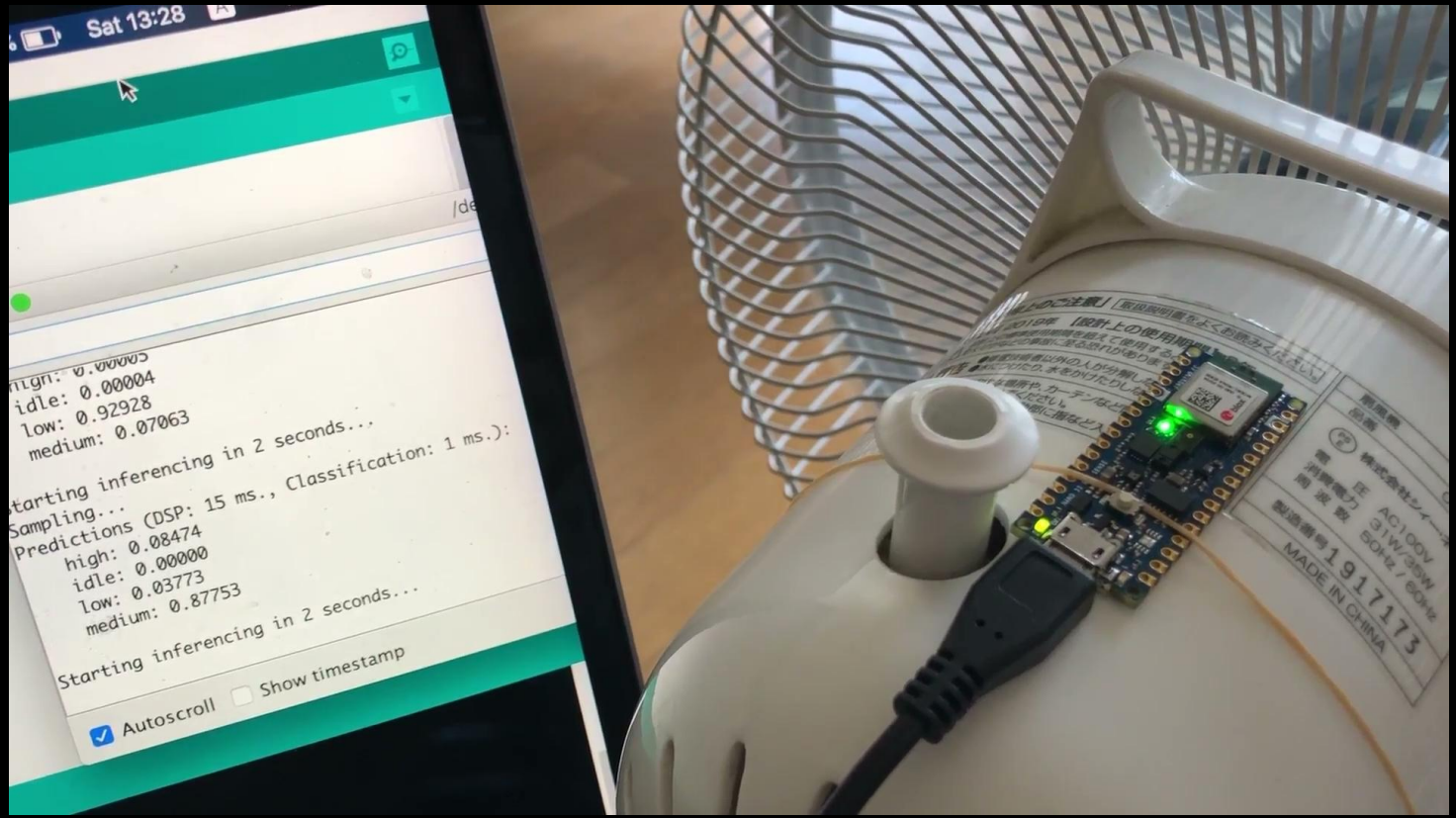
Demo: On-Device Inferencing



OFF

LOW

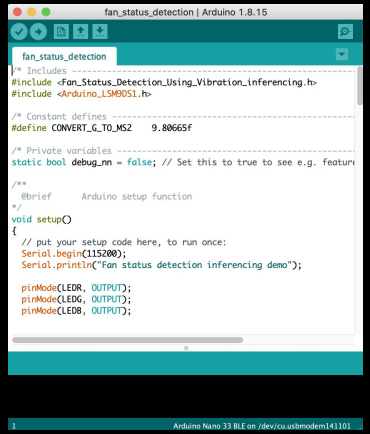
MEDIUM

HIGH

MACHINE LEARNING TOKYO

All code and material of the session

- ➔ Walkthrough of the Arduino Inferencing sketch



- ➔ Github repository for the project source code and documentation
  - ◆ https://github.com/Machine-Learning-Tokyo/edgeai-lab-microcontroller-series

MACHINE LEARNING TOKYO

Brainstorming Session

- Breakout Rooms (Random Teams)
- Think of some edge AI applications, and figure out different blocks
- Summarize and share your ideas by 1-2 members from the team.

WhiteBoards for Brainstorming

Team1:
https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629004925401/f3018a40dd38481a19ebd438080e4fd81d7ab410?sender=u95ce3da66ee17f1954ba5414

Team 2:
https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629005197838/c71484addd603e0de284da41e7329682aafea500?sender=u95ce3da66ee17f1954ba5414

Team 3:
https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629005207313/cfdd36833f34ff6db2cd9aaa5c2b76043c947933?sender=u95ce3da66ee17f1954ba5414

Team 4 (Project Push Up Detection & Counting)
https://app.mural.co/t/mltedgeailab3396/m/mltedgeailab3396/1629005216375/3e7cd6437df6ba9b5392b66fa2c490ab27c36a34?sender=u95ce3da66ee17f1954ba5414

Team 5:
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Next Session

- ➔ Session #3 : Audio Based Application using Microphone on Sep 05 (5:00 PM - 6:30 PM JST)
  - ◆ Will be announced soon on MLT Meetup page.

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END

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