

tinyML® Talks

Enabling Ultra-low Power Machine Learning at the Edge

“How A Middle School Girl Solves a Real-Life Challenge Using TinyML: Gas Leak Detection”

Mithun Das - Distinguished Software Engineer, Cox Automotive

Sashrika Das - 6th Grade Student, East Lyme Middle School

March 25, 2022



www.tinyML.org



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The latest in AI trends, technologies & best practices from Arm and our Ecosystem Partners.

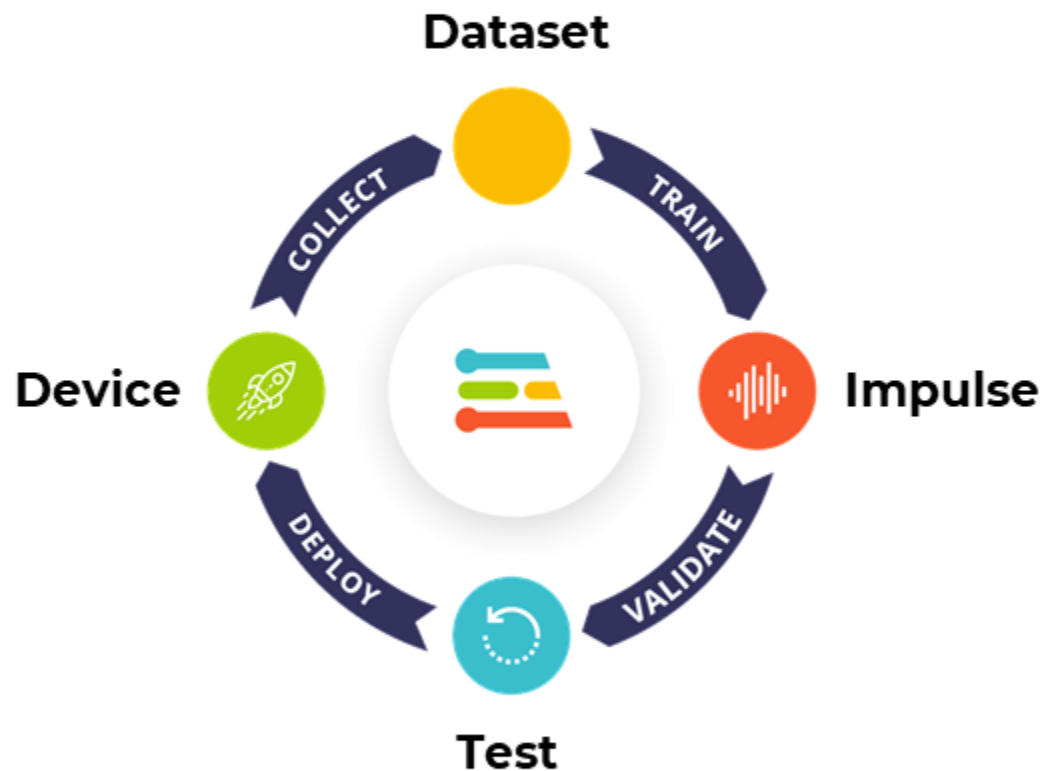
Demos, code examples, workshops, panel sessions and much more!

Fortnightly Tuesday @ 4pm GMT/8am PT

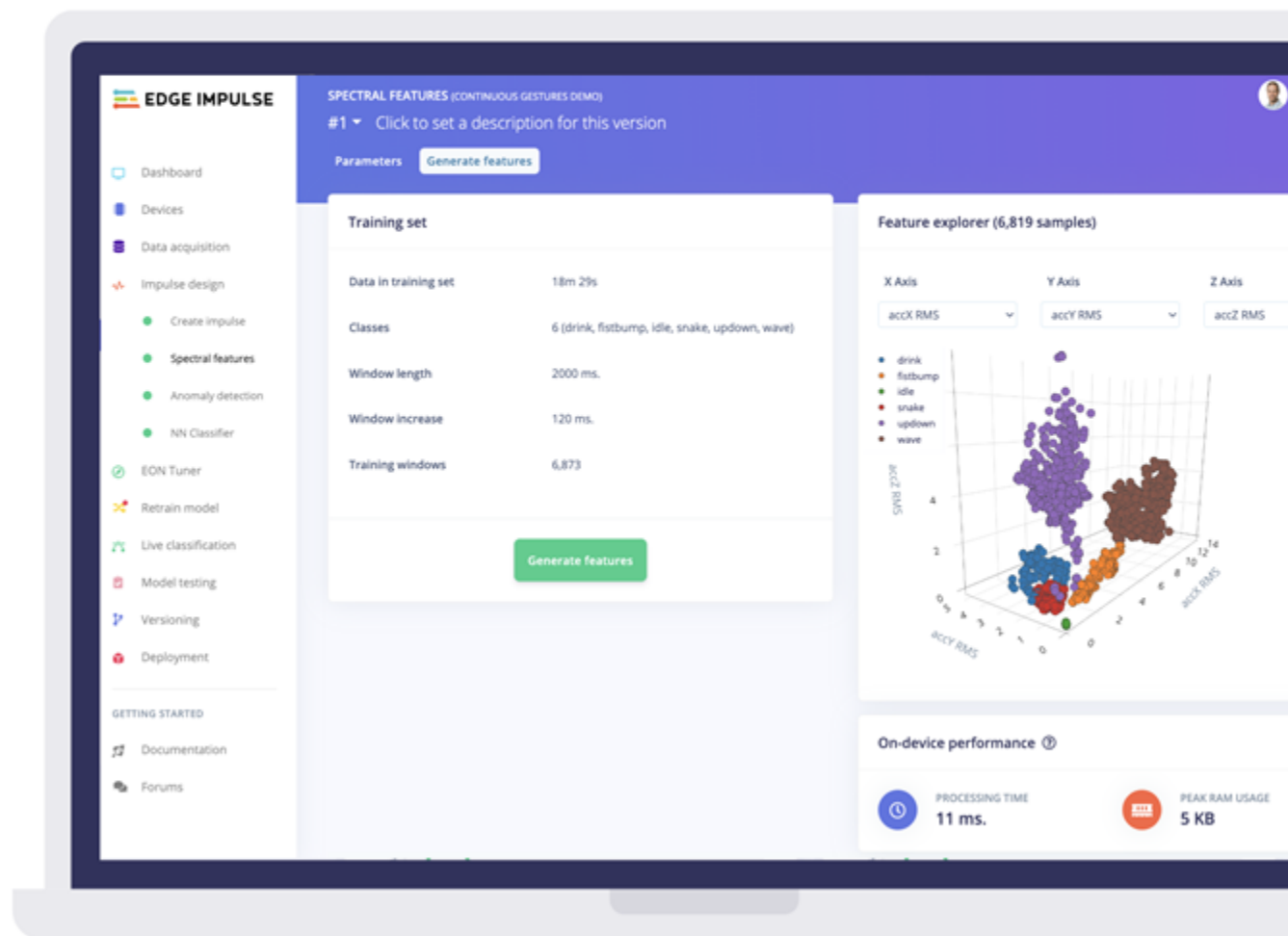
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www.edgeimpulse.com



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Advancing AI research to make efficient AI ubiquitous

Power efficiency

Model design, compression, quantization, algorithms, efficient hardware, software tool

Personalization

Continuous learning, contextual, always-on, privacy-preserved, distributed learning

Efficient learning

Robust learning through minimal data, unsupervised learning, on-device learning

A platform to scale AI across the industry



Perception

Object detection, speech recognition, contextual fusion



Reasoning

Scene understanding, language understanding, behavior prediction



Action

Reinforcement learning for decision making



Edge cloud



Cloud



IoT/IIoT



Automotive



Mobile

SYNTIANT

End-to-End
Deep Learning
Solutions
for
TinyML & Edge AI



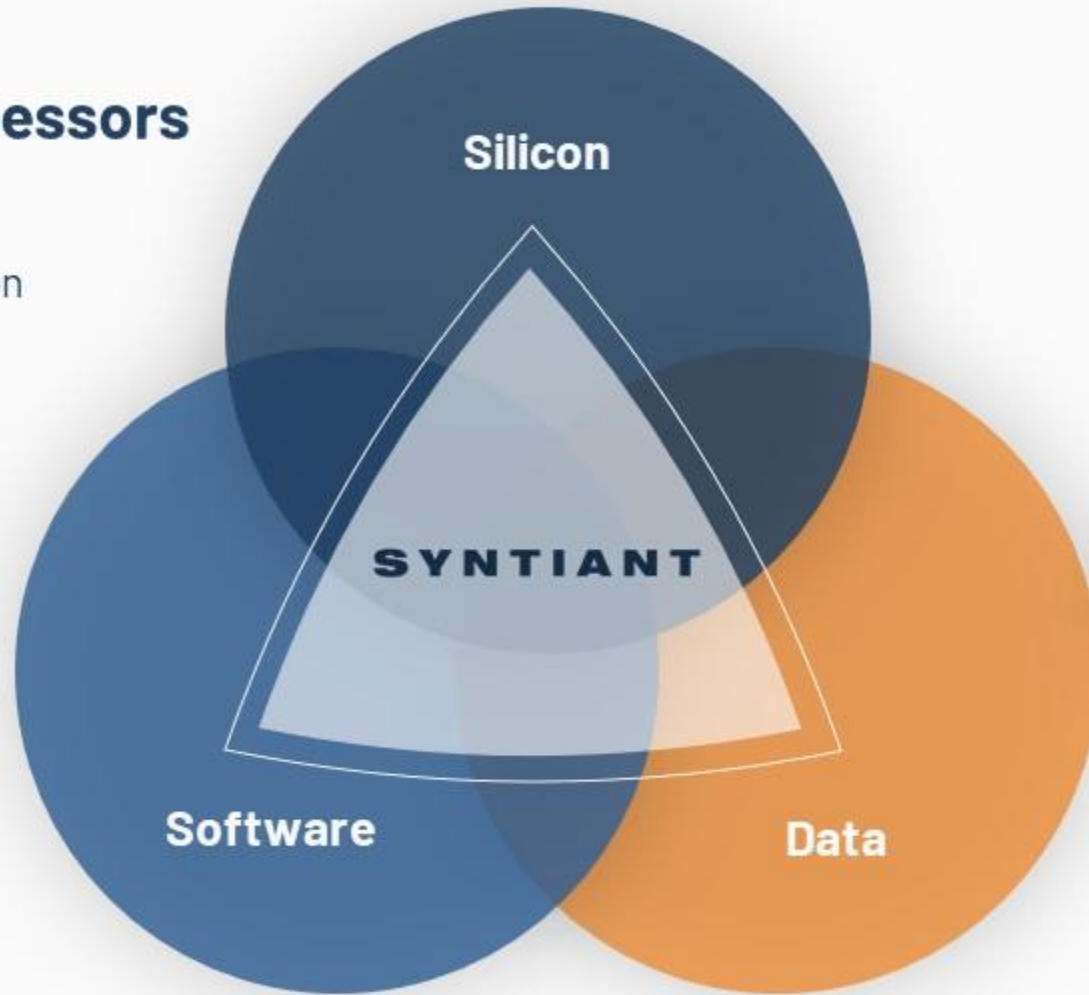
Neural Decision Processors

- At-Memory Compute
- Sustained High MAC Utilization
- Native Neural Network Processing



ML Training Pipeline

- Enables Production Quality Deep Learning Deployments



Data Platform

- Reduces Data Collection Time and Cost
- Increases Model Performance

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Fastest Video Analytics Solutions on Arm CPUs



AI Trailblazers Award
Winner

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Explain ML models and relate the function
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40nm/28nm process Automotive 32-bit MCUs
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Core technologies

AI

A broad set of high-power and energy-efficient embedded processors

Security & Safety

Comprehensive technology and support that meet the industry's stringent standards



Digital & Analog & Power Solution

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Cloud Native

Cross-platforms working with partners in different verticals and organizations

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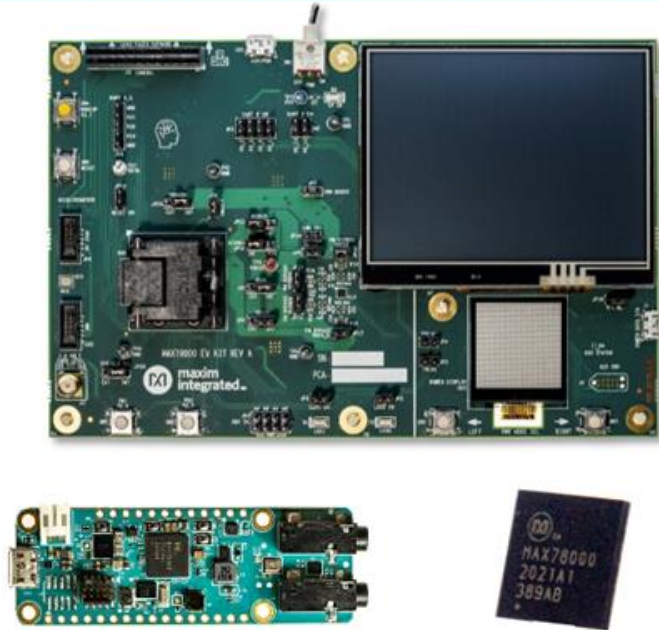


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Maxim Integrated: Enabling Edge Intelligence

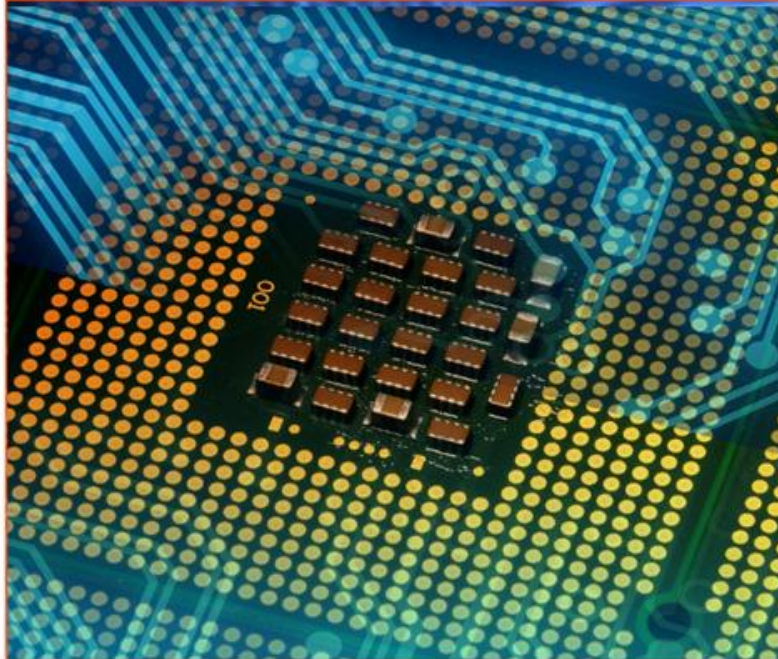
Advanced AI Acceleration IC



The new MAX78000 implements AI inferences at low energy levels, enabling complex audio and video inferencing to run on small batteries. Now the edge can see and hear like never before.

www.maximintegrated.com/MAX78000

Low Power Cortex M4 Micros



Large (3MB flash + 1MB SRAM) and small (256KB flash + 96KB SRAM, 1.6mm x 1.6mm) Cortex M4 microcontrollers enable algorithms and neural networks to run at wearable power levels.

www.maximintegrated.com/microcontrollers

Sensors and Signal Conditioning



Health sensors measure PPG and ECG signals critical to understanding vital signs. Signal chain products enable measuring even the most sensitive signals.

www.maximintegrated.com/sensors



Latent AI

Adaptive AI for the Intelligent Edge

[Latentai.com](https://latent.ai)



Micr .ai



NXP



seeed studio

The IoT Hardware Enabler



Build Smart IoT Sensor Devices From Data

SensiML pioneered TinyML software tools that auto generate AI code for the intelligent edge.

- End-to-end AI workflow
- Multi-user auto-labeling of time-series data
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We enable the creation of production-grade smart sensor devices.



sensiml.com

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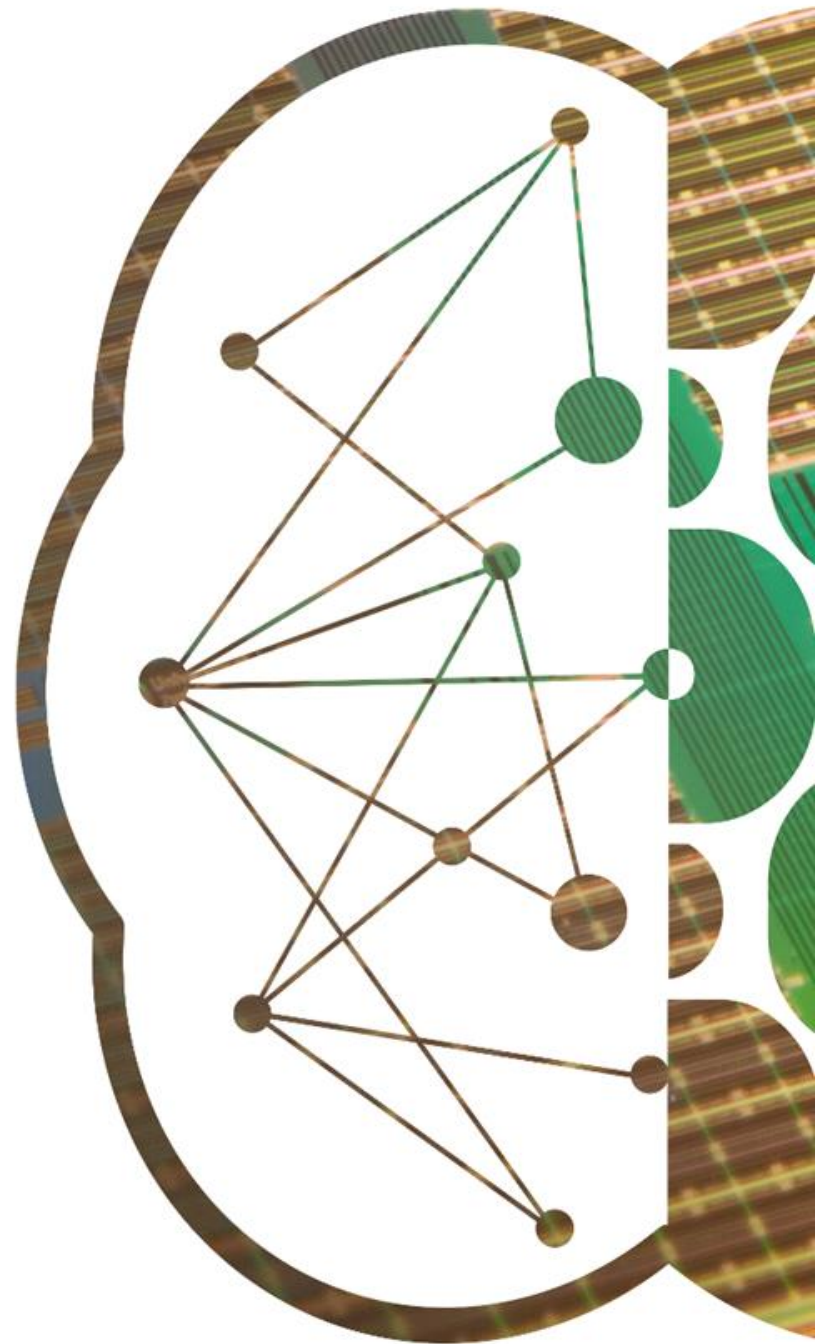
life.augmented



SynSense

SynSense builds **sensing and inference** hardware for **ultra-low-power** (sub-mW) **embedded, mobile and edge** devices. We design systems for **real-time always-on smart sensing**, for audio, vision, IMUs, bio-signals and more.

<https://SynSense.ai>



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Miniature dreams can come true...

March 28-30, 2022

Hyatt Regency San Francisco Airport

<https://www.tinyml.org/event/summit-2022/>



*The Best Product of the Year and the Best Innovation of the Year awards are open for nominations between **November 15 and March 14.***

tinyML Research Symposium 2022

March 28, 2022

<https://www.tinyml.org/event/research-symposium-2022>

More sponsorships are available: sponsorships@tinyML.org



Our next tinyML Trailblazers Series

Success Stories with Eric Pan
(Founder, Seed Studio and Chaihuo Makerspace)

LIVE ONLINE April 6th, 2022 at 8 am PST



Register now!





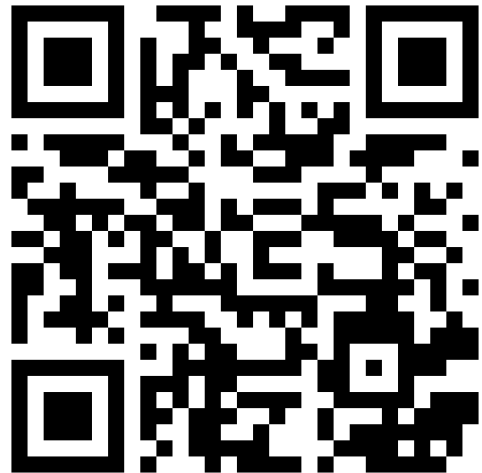
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<https://www.meetup.com/tinyML-Enabling-ultra-low-Power-ML-at-the-Edge/>



2.7k members
&
5.7k followers

The tinyML Community

<https://www.linkedin.com/groups/13694488/>





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tinyML Summit 2021 tiny Talks: Person Detection... 18:26

tinyML Summit 2021 tiny Talks: Using Neural... 19:03

tinyML Summit 2021 Keynote: Adaptive Neural... 55:15

tinyML Summit 2021 Keynote: milliJoules for... 99:43

tinyML Summit 2021 Market Opportunities for Edge AI 51:28



Next tinyML Talks

Date	Presenter	Topic / Title
Tuesday, April 5	Daniel Konegen, Embedded AI and data science engineer, Hahn-Schickard Marcus Rüb, Research assistant, Hahn-Schickard	AutoFlow - an open source Framework to automatically implement neural networks on embedded devices

Webcast start time is 9:30 am Pacific time

Please contact talks@tinymml.org if you are interested in presenting



Reminders

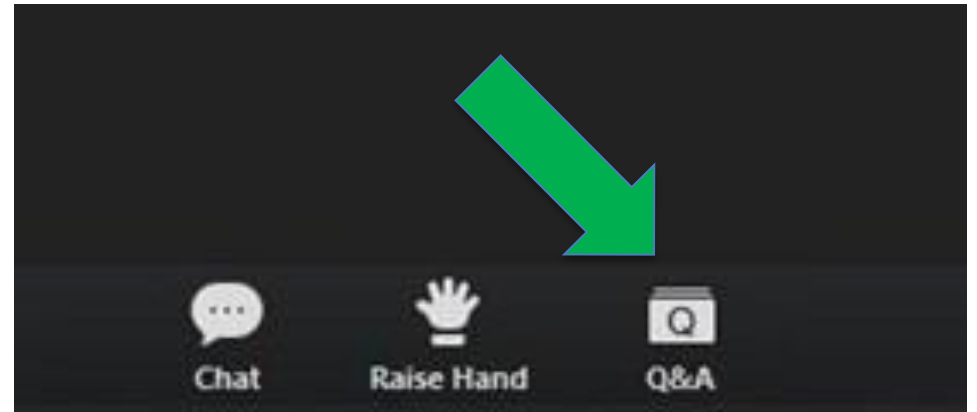
Slides & Videos will be posted tomorrow

Please use the Q&A window for your questions



tinyml.org/forums

youtube.com/tinyml





Mithun Das



Mithun Das is a distinguished software engineer at Cox Automotive with 17 years of experience in software, ambassador at Edge Impulse & Balena. He obtained bachelors degree in “Information Technology” from IIST, India. At Cox, innovation is in their culture which brought Mithun to the world IoT. For last 4-5 years, he has been working on IoT and ML for good. He has implemented many proof of concepts including low cost contact tracing, smart parking reducing carbon emission, saving peatlands using tinyML, smart collar for elephant, hearing substitution using haptic feedback are few of them.



Sashrika Das



Sashrika Das is a 6th grade student at East Lyme Middle School in Connecticut, USA. She is passionate about Internet of Things and programming. She participates in virtual contests such as “The coolest project” , “do your:bit”. She has started learning tinyML recently with guidance from her parent, and created proof of concept of some of her ideas.

Gas Leak Detection

Solving real-life problem using tinyML

Why We Use Oil Tank?



- Used in boiler heating systems
- Stores diesel/propane fuel
- Used to heat up rooms and water
- Most common in older houses and apartments in Northeast of America

Cons of Using Oil Tank

- Regular maintenance required
- High repair cost
- Not monitored 24x7



Leakage from Tank



- Cracks or holes can form due to many reasons
- Unnoticed small leakage may become uncontrollable
- Posses health issues for human & pets
- May contaminate water supply
- Increase repair cost

How About Early Detection?

Early detection can help in :

- Reducing health issues
- Reduce risk of contamination
- Reduce repair cost



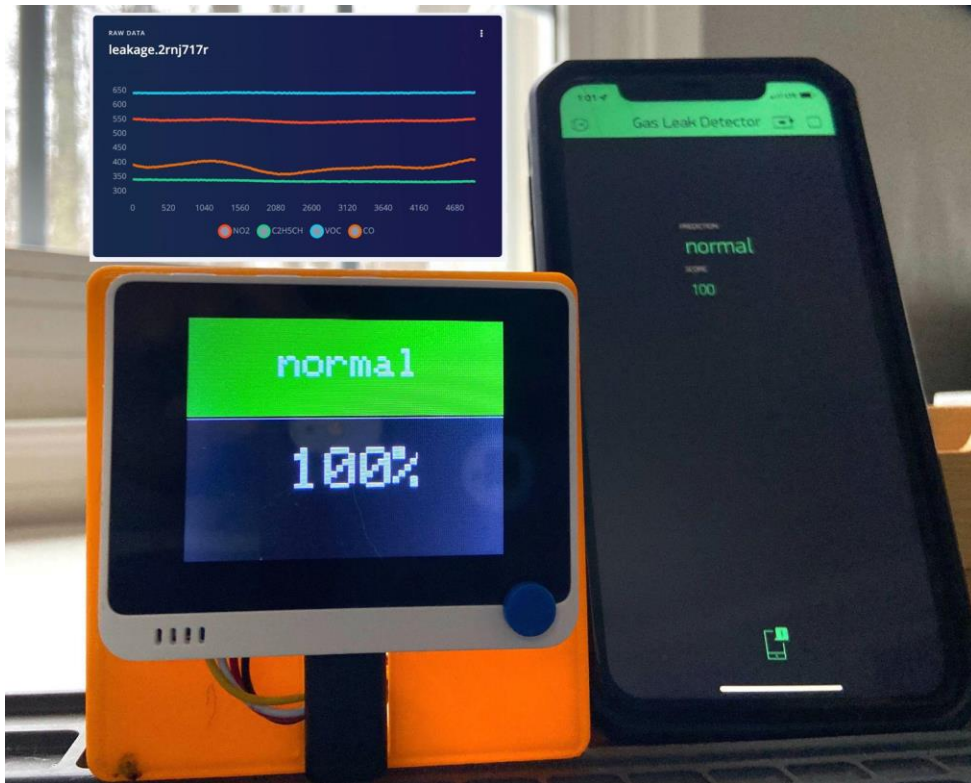
How Can We Detect?



- Smell the air
- Identify if diesel or propane is in the air
- Send Text or Notification to mobile phone

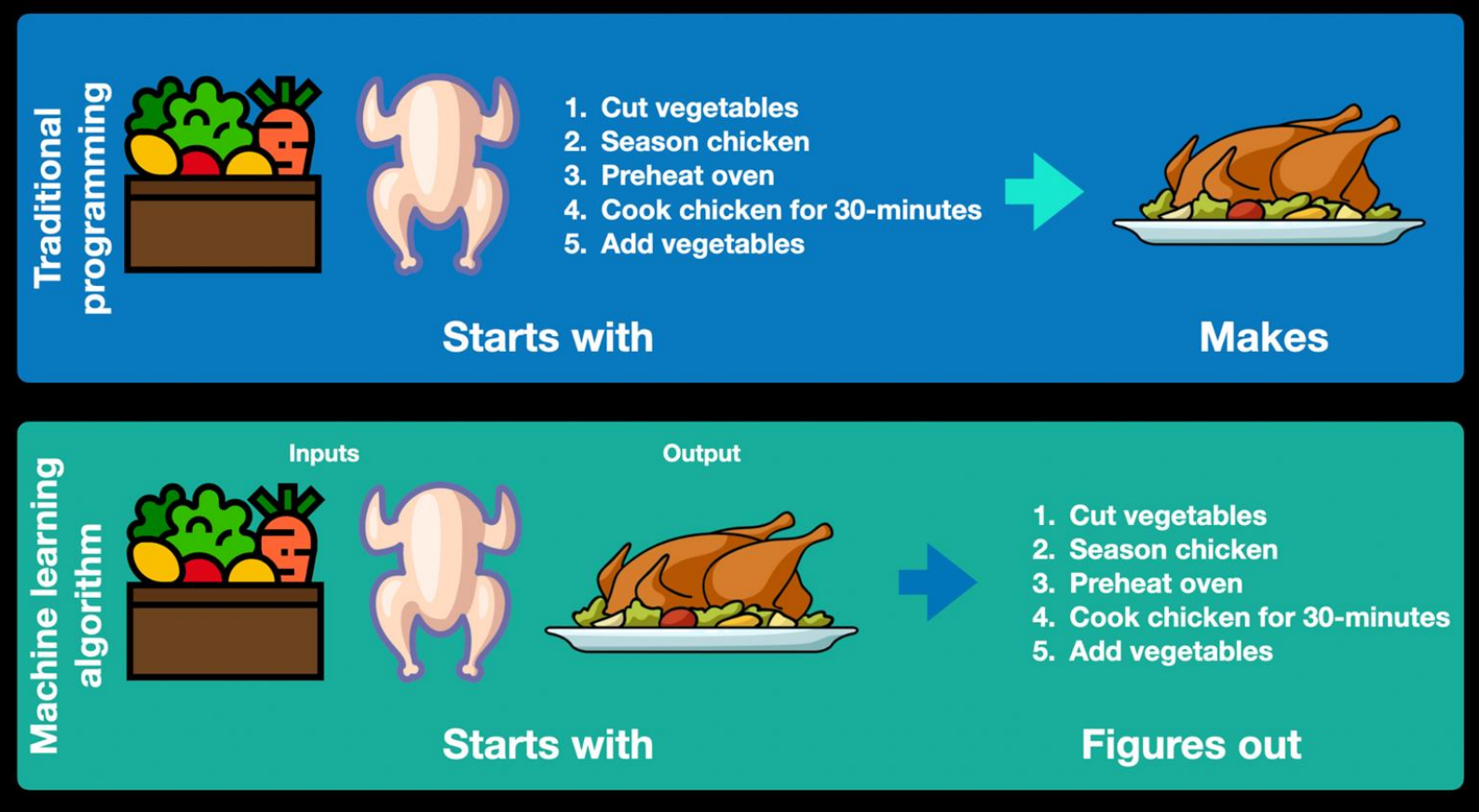


Smart Oil Leak Detection



- Multichannel gas sensor collects data from air
- Microcontroller runs tinyML to classify data
- Microcontroller sends alert to Blynk when diesel is detected in the air

Why I chose ML over If-else



[Insert demo video here]



Hardware



Seed Wio Terminal

Grove Multichannel Gas Sensor

5V Mini Fan

3D printed case (optional)

Softwares



**EDGE
IMPULSE**

- Edge Impulse Studio
- Arduino IDE
- Blynk App



Building the model

The screenshot shows a web interface titled "CREATE IMPULSE (GAS_LEAK_DETECTOR)" with a user profile "sashrikad_gmail_com". A green notification bar at the top states: "Successfully stored impulse. Configure the signal processing and learning blocks in the navigation bar." The interface is divided into four main panels:

- Time series data (Red panel):** Shows "Input axes (4)" as NO2, C2H5CH, VOC, and CO. It includes sliders for "Window size" and "Window increase", both set to 2000 ms. A "Frequency (Hz)" input is set to 100. A "Zero-pad data" checkbox is checked.
- Raw Data (White panel):** The "Name" field contains "Raw data". Under "Input axes (4)", checkboxes for NO2, C2H5CH, VOC, and CO are all checked.
- Neural Network (Keras) (Blue panel):** The "Name" field contains "Neural Network (Keras)". Under "Input features", the checkbox for "Raw data" is checked. Under "Output features", it is set to "2 (leakage, normal)".
- Output features (Green panel):** Shows "2 (leakage, normal)" and a "Save Impulse" button.

At the bottom, there are two dashed boxes: "Add a processing block" (with a lightning bolt icon) and "Add a learning block" (with a flask icon).

Data collection

Create Impulse

Define NN Architecture

Train



Deploy TinyML on Wio Terminal

Select optimizations *(optional)*

Model optimizations can increase on-device performance but may reduce accuracy. Click below to analyze optimizations and see the recommended choices for your target. Or, just click Build to use the currently selected options.



Enable EON™ Compiler

Same accuracy, up to 50% less memory. Open source.



Available optimizations for Neural Network (Keras)

Quantized (int8) ★	RAM USAGE	LATENCY	CONFUSION MATRIX						
Click to select	2.8K	4 ms	<table><tr><td>100</td><td>0</td><td>0</td></tr><tr><td>8.3</td><td>91.7</td><td>0</td></tr></table>	100	0	0	8.3	91.7	0
100	0	0							
8.3	91.7	0							
This optimization is recommended for best performance.	FLASH USAGE	ACCURACY							
	50.9K	95.59%							

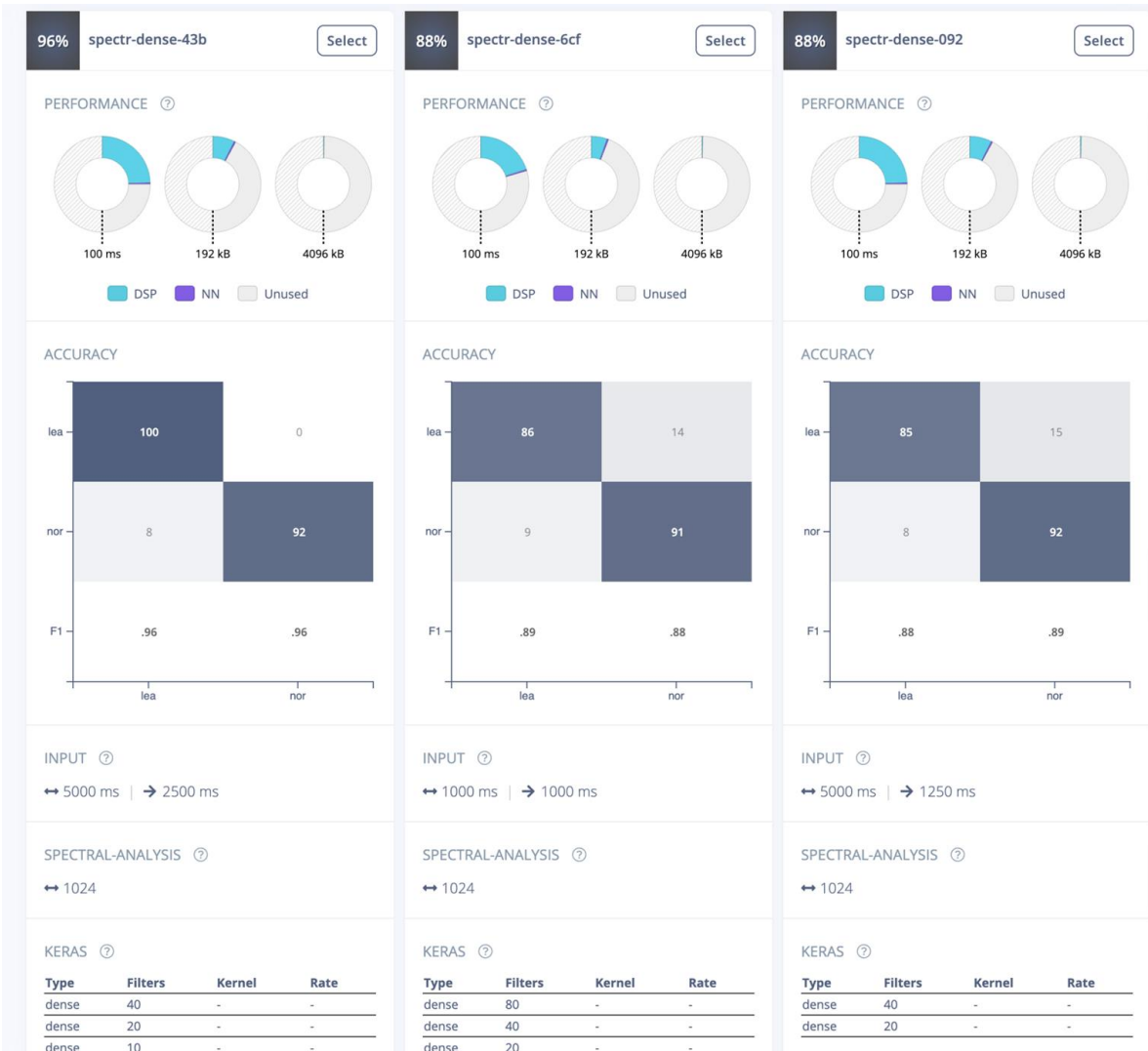
Unoptimized (float32)	RAM USAGE	LATENCY	CONFUSION MATRIX						
Currently selected	5.2K	15 ms	<table><tr><td>100</td><td>0</td><td>0</td></tr><tr><td>2.8</td><td>97.2</td><td>0</td></tr></table>	100	0	0	2.8	97.2	0
100	0	0							
2.8	97.2	0							
	FLASH USAGE	ACCURACY							
	147.2K	98.53%							

Estimate for Seeed Studio Wio Terminal (Cortex-M4F 120MHz)

Build

- Download the model as zip
- Import to Arduino IDE
- Upload the sketch

EON Tuner



- Raw processing had high accuracy during testing but suffered with live data
- Needed to improve the model
- EON tuner suggested Spectral analysis instead of Raw data
- Accuracy dropped during testing but performed much better with live data



Other Challenges

- Collecting wide variety of data
- Indoor vs outdoor prediction
- Initial misclassification due to other smells



Questions?



AI Thermal Camera for Safe Camping



Hardware:

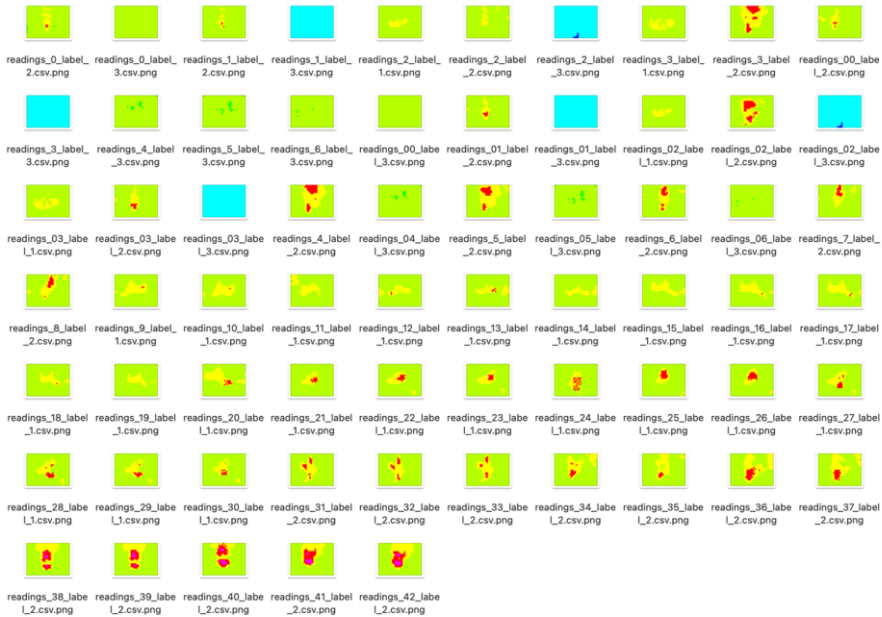
- Wio Terminal
- Lorawan GPS chassis
- Batter Chassis

Software:

- Edge Impulse
- Arduino IDE
- Amazon Web Service
- Helium Console

Data Collection

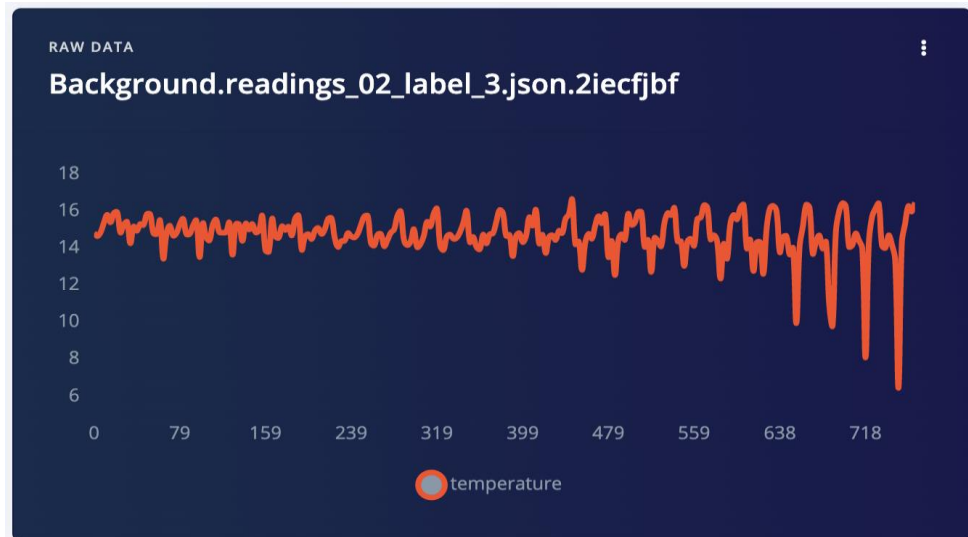
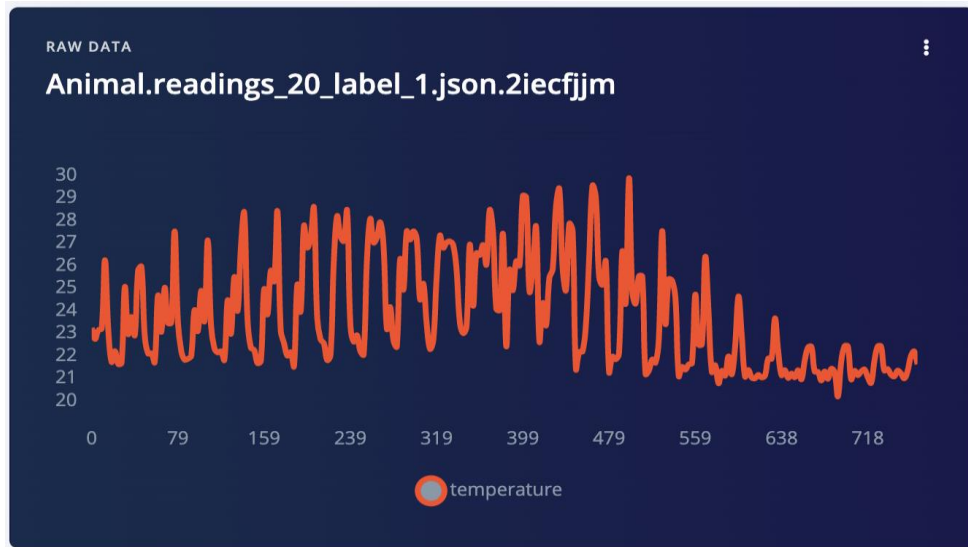
You, 4 months ago | 1 author (You)
1 | 20.37, 20.44, 20.55, 21.06, 21.11, 20.99, 21.48, 21.57, 22.05, 22.23, 22.69, 23.23, 24.81, 26.75, 24.74, 25.10, 25.88, 23.68, 22.19, 22.14, 21.82, 21.48, 21.34, 21.10, 21.18, 21.10



- Data collected as CSV
- CSV converted to JSON and signed by HMAC key
- Data forwarded to Edge Impulse using CLI command

<https://www.hackster.io/mithun-das/ai-powered-thermal-camera-for-safe-camping-8fc887>
<https://www.hackster.io/mithun-das/ai-thermal-camera-for-safe-camping-seeed-helium-aws-v2-c0d28b>

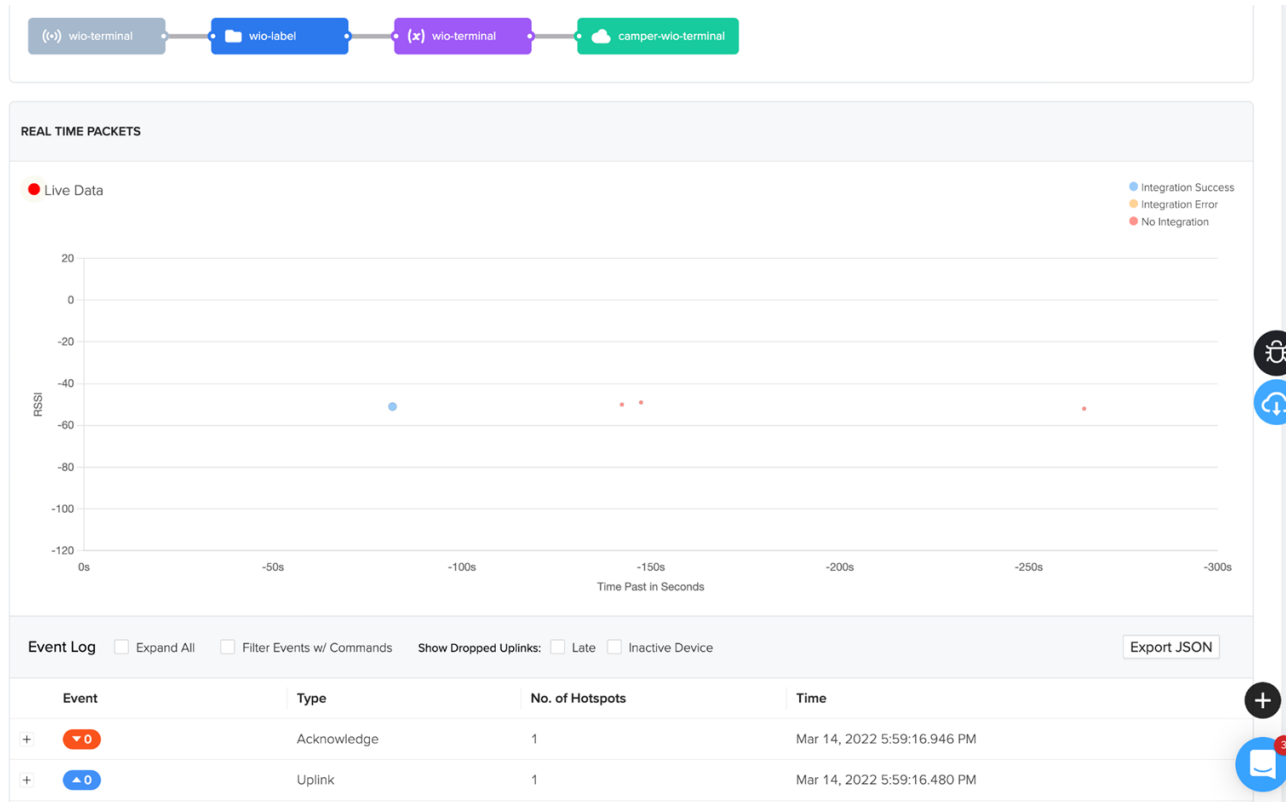
Continued...



- The IR thermal camera carries a 32x24 array of sensor value
- Data represented as 768 (32x24) discrete time series data



Integration with Helium & AWS



- Add device to helium console
- Add AWS integration
- Create AWS IoT rule
- Create lambda trigger to send message via telegram

Questions?



<https://www.hackster.io/mithun-das>



<https://twitter.com/tweetmithund>



<https://www.linkedin.com/in/connectmithundas/>





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