

tinyML® Talks

Enabling Ultra-low Power Machine Learning at the Edge

“Battery optimized people counting using FIR and AI”

Łukasz Szelejewski - Kontakt.io

Dawid Crivelli - Kontakt.io

April 7, 2022



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Additional Sponsorships available – contact Olga@tinyML.org for info

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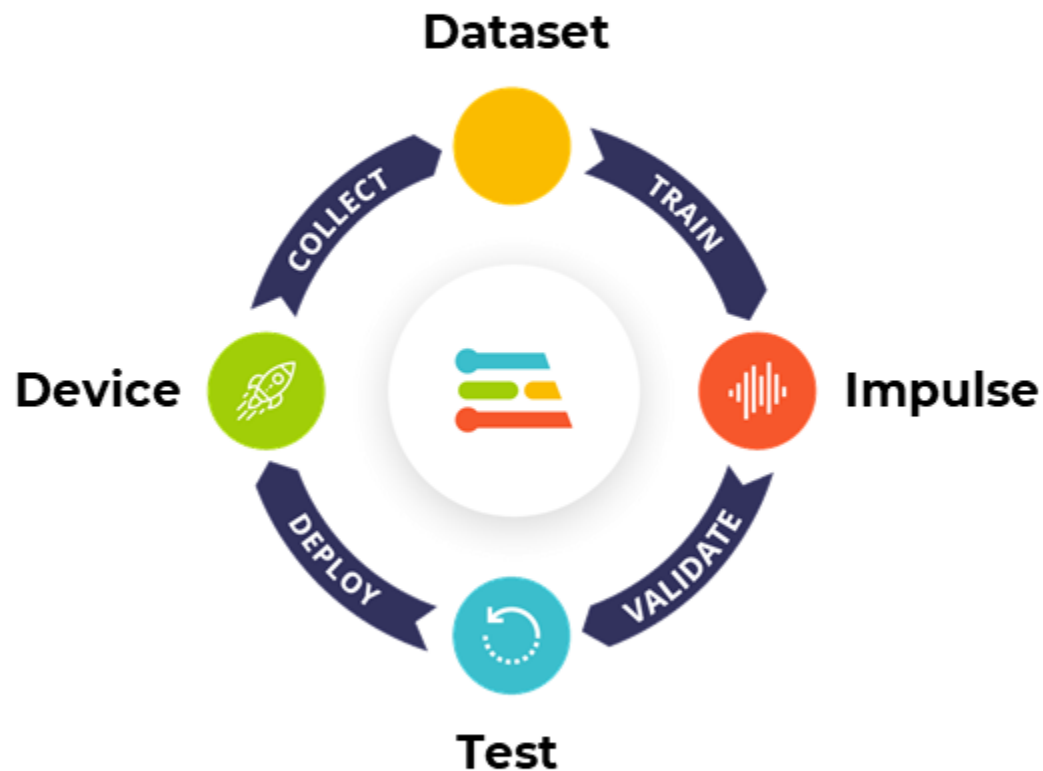
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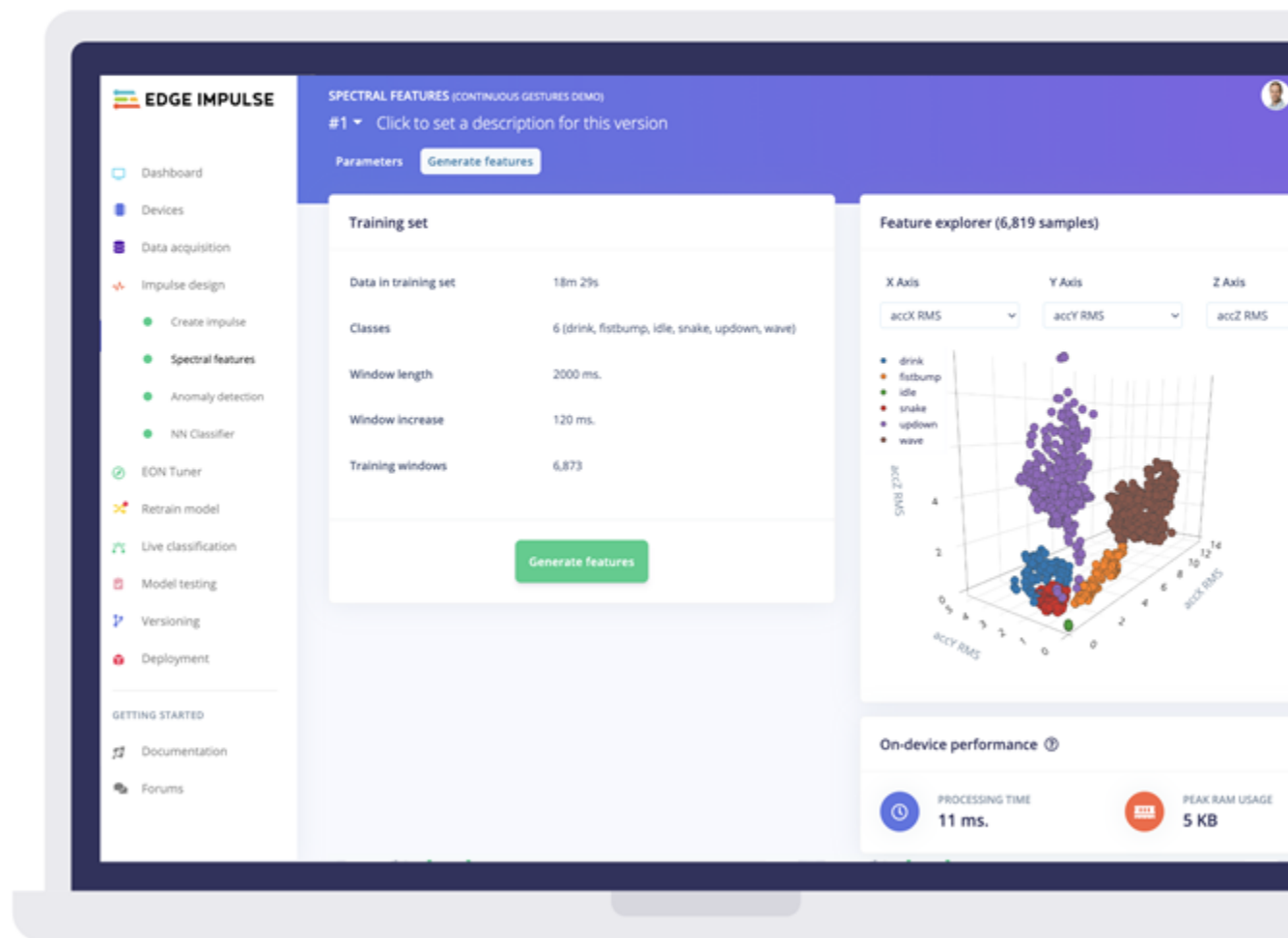
Fortnightly Tuesday @ 4pm GMT/8am PT

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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

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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



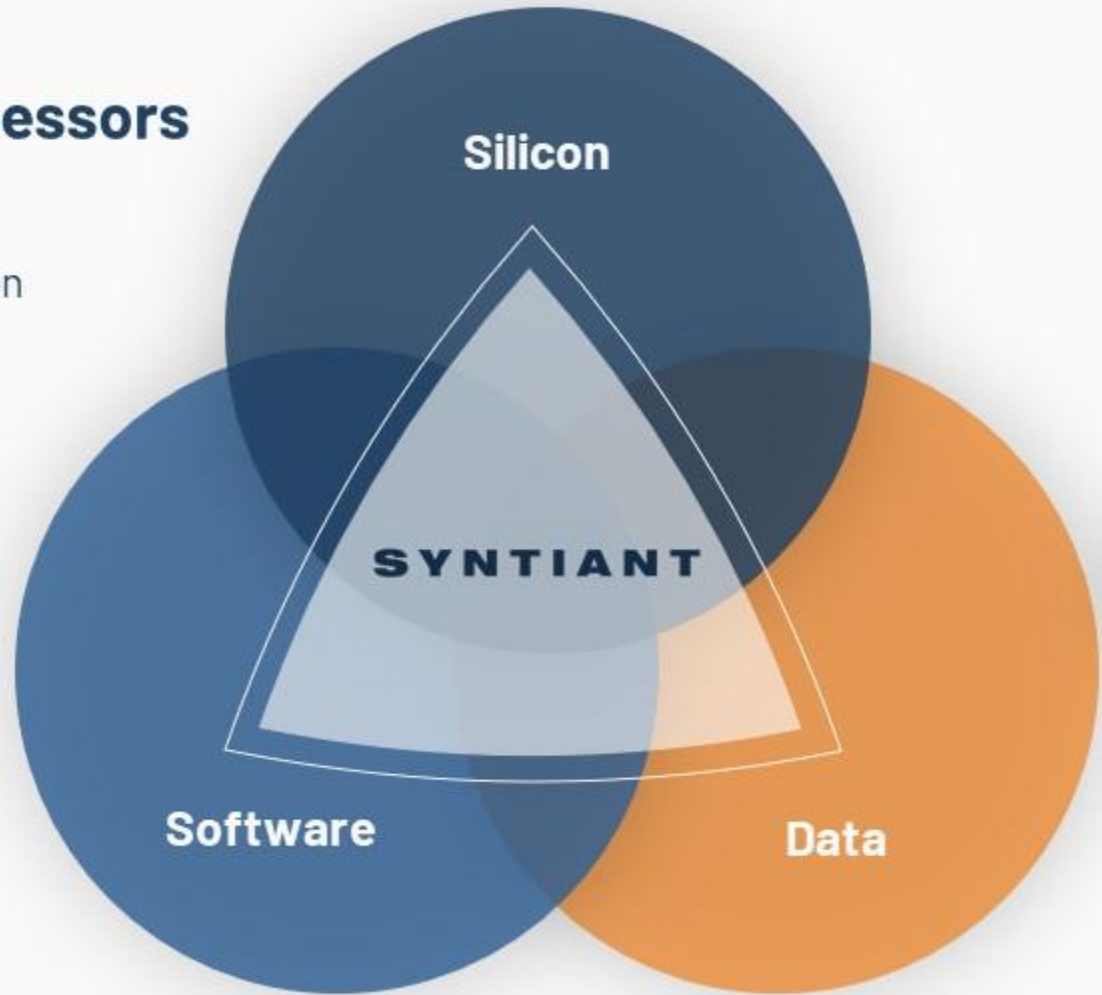
Neural Decision Processors

- 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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Pre-built Edge AI sensing modules, plus tools to build your own

Reality AI solutions

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indoor and outdoor use cases

Solution for industrial anomaly detection

Pre-built automotive solution that lets cars
“see with sound”

Reality AI Tools[®] software

Build prototypes, then turn them into
real products

Explain ML models and relate the function
to the physics

Optimize the hardware, including
sensor selection and placement

BROAD AND SCALABLE EDGE COMPUTING PORTFOLIO

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Arm®-based High-end 32 & 64-bit MPUs
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Innovative process tech (SOTB), Energy harvesting

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Ultra-low Energy 8 & 16-bit MCUs
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High Power Efficiently 32-bit MCUs
Motor control, Capacitive touch, Functional safety, GUI



40nm/28nm process Automotive 32-bit MCUs
Rich functional safety and embedded security features

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

Winning Combinations that combine our complementary product portfolios

Cloud Native

Cross-platforms working with partners in different verticals and organizations

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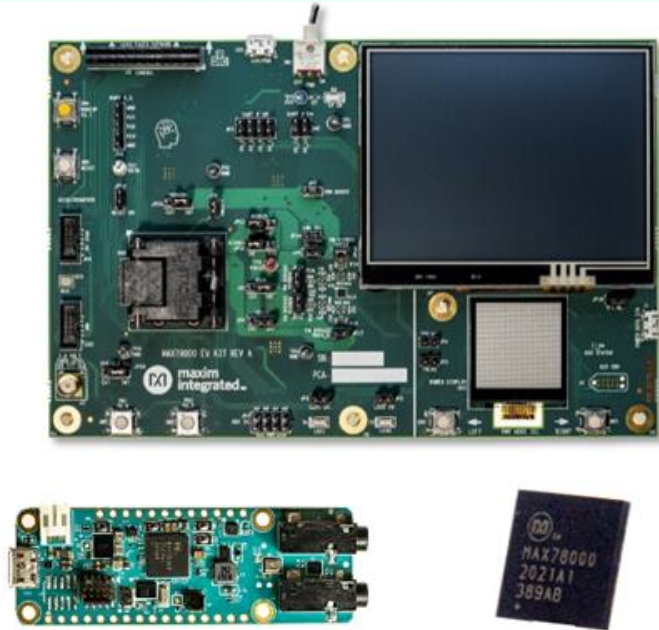


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Maxim Integrated: Enabling Edge Intelligence

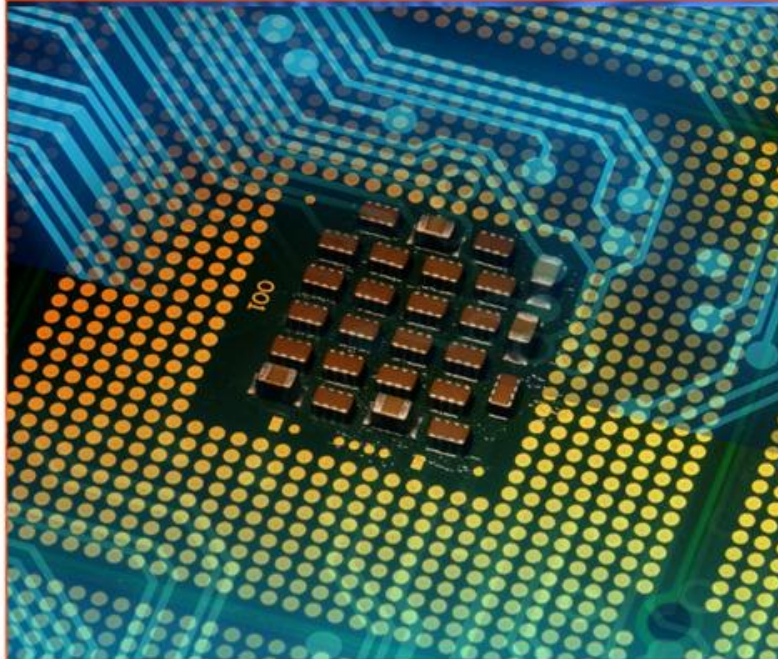
Advanced AI Acceleration IC



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

latent.ai

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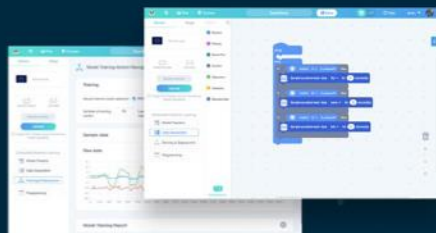
NXP

Deploy TinyML into the Real World - Plug and Play ML



Sensors:

- modulated and ready-to-use sensors to simplify the setup process
- support 500+ grove modules



Codecraft:

- no code Programming platform to Get Started With TinML
- supports Arduino, Python, C or JavaScript etc.



Edge Impulse:

- to optimize data utilization and enable deploy a machine learning model faster than ever



TensorFlow Lite:

- to easily train low memory usage machine learning models



Motion /Gesture/Speech /Smell/ Sports
Barcode/Face/Image



Artificial Nose



AI Thermal Camera for Safe Camping



Azure IoT Squirrel Feeder



Wio Terminal:

- completed AI platform --- integrated with a 2.4" LCD Screen, onboard IMU (LIS3DHTR), microphone, buzzer, microSD card slot, light sensor, infrared emitter(IR 940nm)

Sense

Train

Inference

Applications



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
- Code transparency and customization at each step in the pipeline

We enable the creation of production-grade smart sensor devices.



sensiml.com

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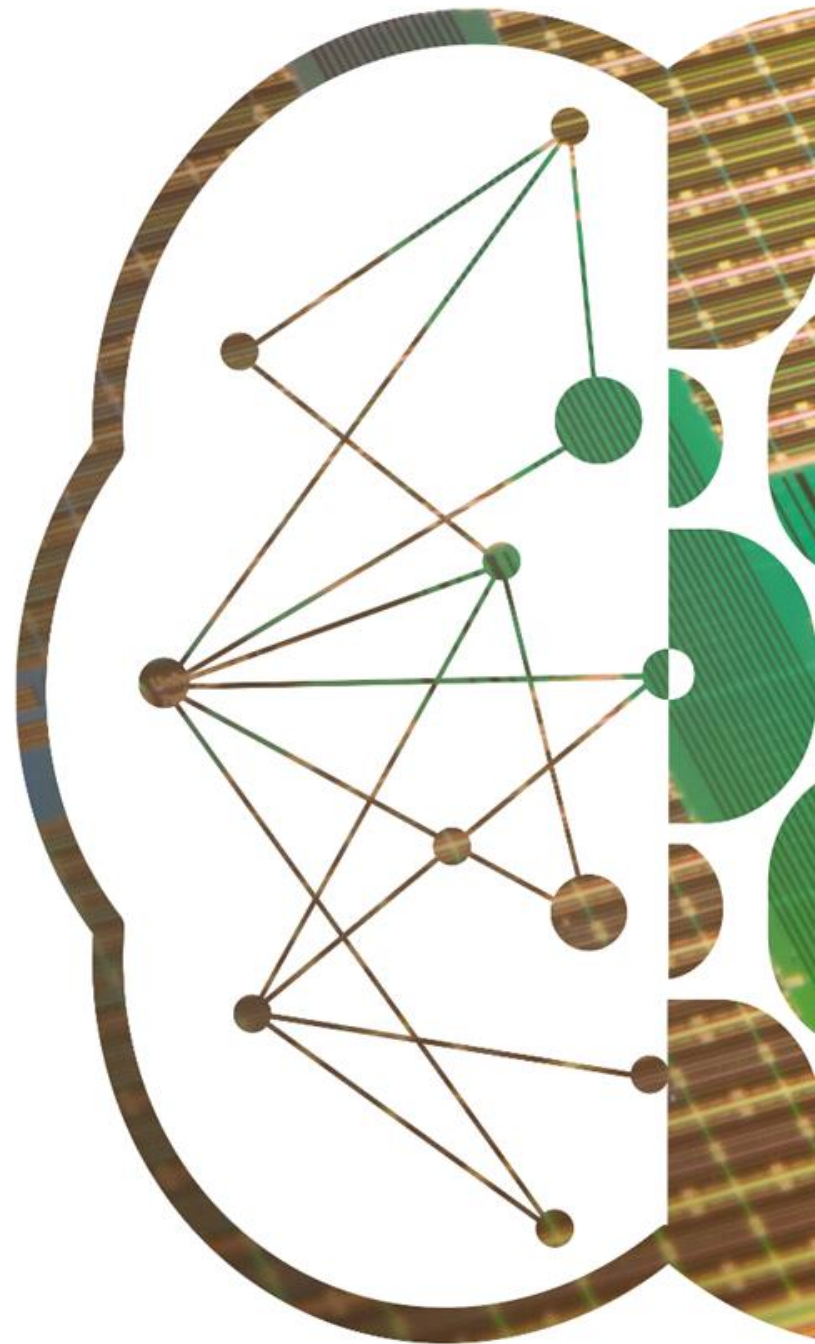
life.augmented



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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The logo for Grovety Inc. features a green lightning bolt icon followed by the text "Grovety Inc." in a bold, uppercase sans-serif font.





tinyML Summit 2022

Miniature dreams can come true...

March 28-30, 2022

Hyatt Regency San Francisco Airport

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



Presentations are available on www.tinyml.org and that videos will be available on www.youtube.com/tinyml

tinyML Research Symposium 2022

March 28, 2022

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

More sponsorships are available: sponsorships@tinyml.org



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tinyML - Enabling ultra-low Power ML at the Edge

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



2.7k members
&
6.1k followers

The tinyML Community

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





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Next tinyML Talks

Date	Presenter	Topic / Title
Wednesday, April 8	Ying-Chen (Daphne) Chen Assistant Professor, Northern Arizona University	Novel Device and Materials in Emerging Memory for Neuromorphic Computing

Webcast start time is 8:00 am Pacific time

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



Reminders

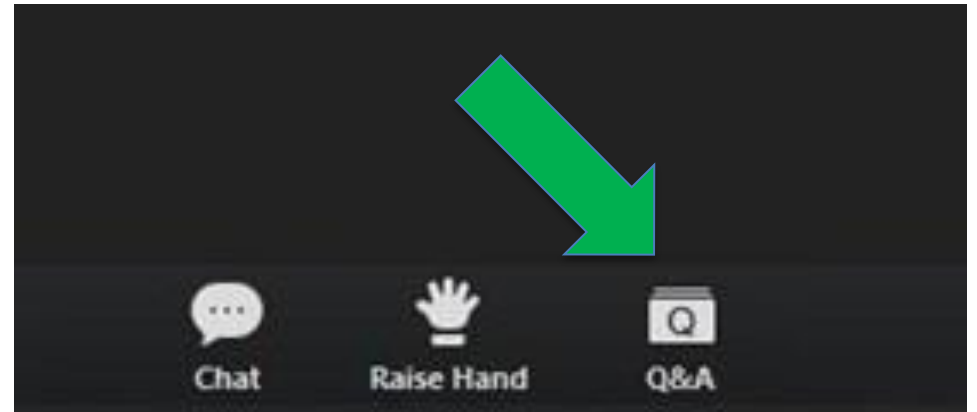
Slides & Videos will be posted tomorrow

Please use the Q&A window for your questions



tinyml.org/forums

youtube.com/tinyml



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Łukasz Szelejewski



Software engineer by education, embedded engineer by passion. Since early days focusing on high performance and real time systems. Before joining Kontakt.io was working on a variety of public safety systems at Motorola Solutions. Currently managing R&D of hardware products at Kontakt.io



Dawid Crivelli



PhD of Physics. True Full-stack embedded engineer, developing new products from bare metal to Cloud. Key person behind logic in Portal Beam.

March 2022

Portal Beam

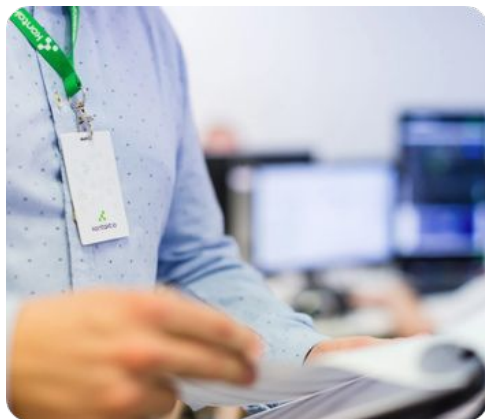
Battery optimised people counting
using FIR and AI





2013

Started operations with offices in San Francisco, New York, Berlin and Krakow



1,200

Partners big and small. Across industries, from transportation to manufacturing, from healthcare, to airports, governments or public spaces, we build together



>2,300,000

IoT tags and sensors deployed, and managed through our Cloud



Portal Beam technical details

- Bluetooth LE connectivity
- IR room level presence Detection
- Environmental sensors
- Battery operated
Up to 4 Years



- Privacy ensured by Low Resolution thermal camera
- Dedicated NN processing CPU
- Optional external power supply



Functionality



Room occupancy | Footfall | Room presence | Environmental sensing | Air Quality monitoring

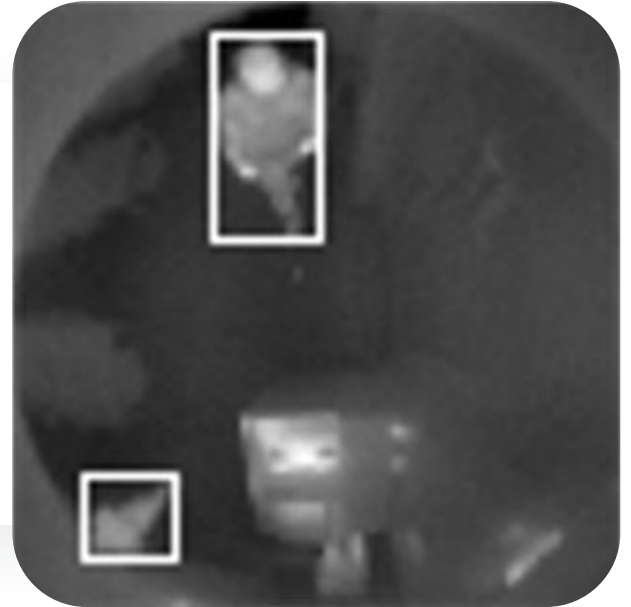


Challenges



Wide angle camera = fisheye effect

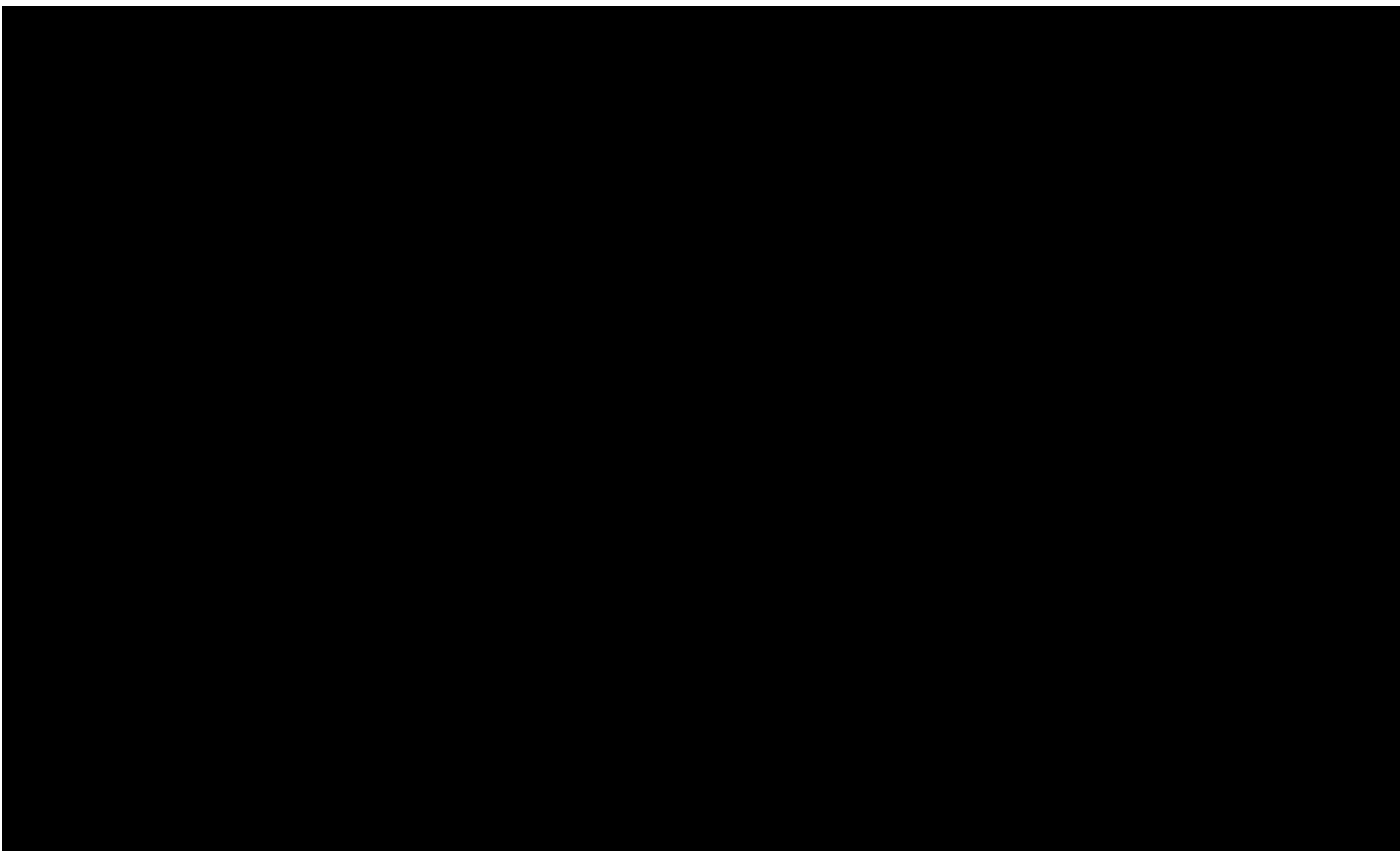
- + Large area coverage using single device
- Radial picture distortion
- Details are lost at higher angles
- Difficulties in coordinates mapping





Low resolution

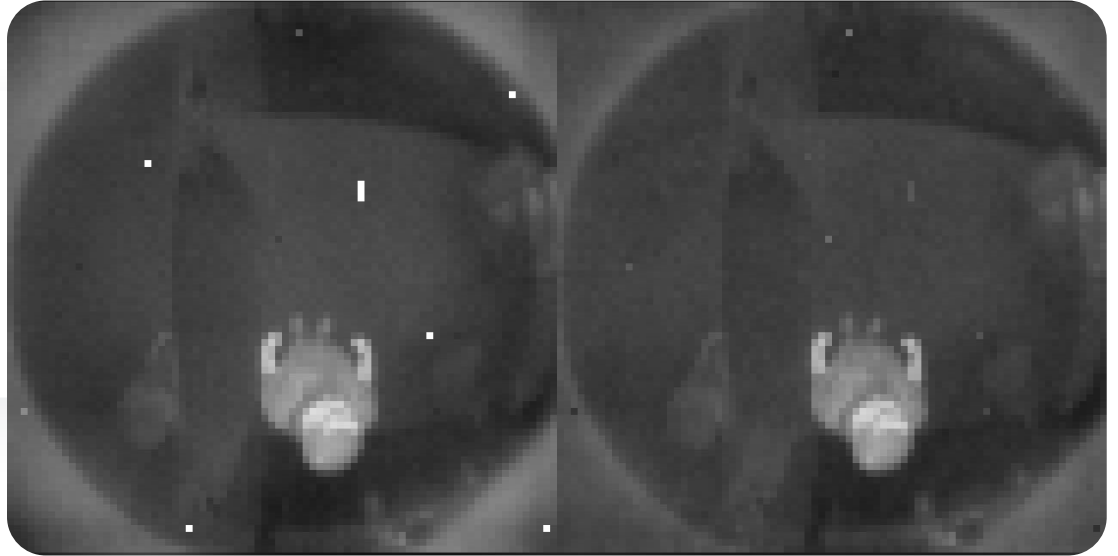
- + Limited power consumption
- + Low compute power requirements
- + Privacy – low risk of data exposure
- Difficult to distinguish between different objects
- Image attribution must be supported by additional camera





Bad pixels

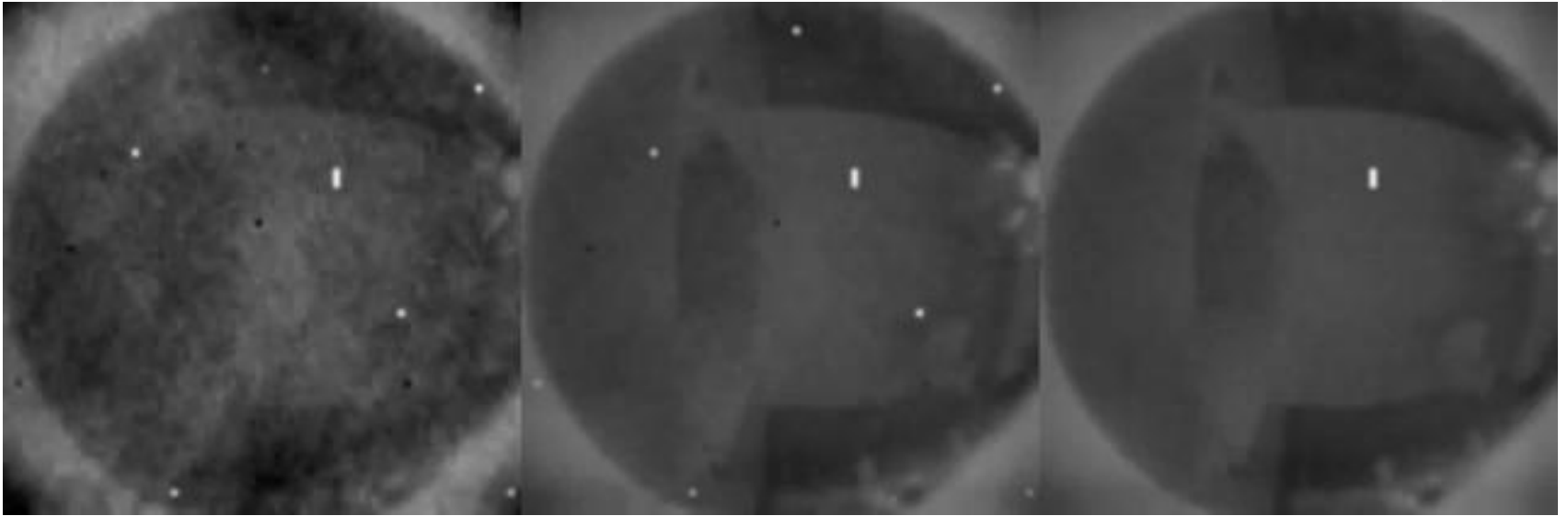
- Bad pixels impacts calibration





Noise

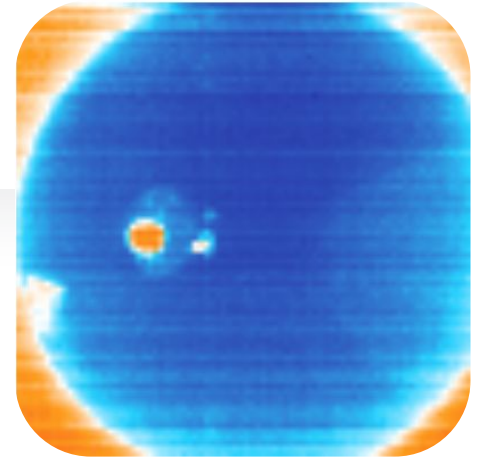
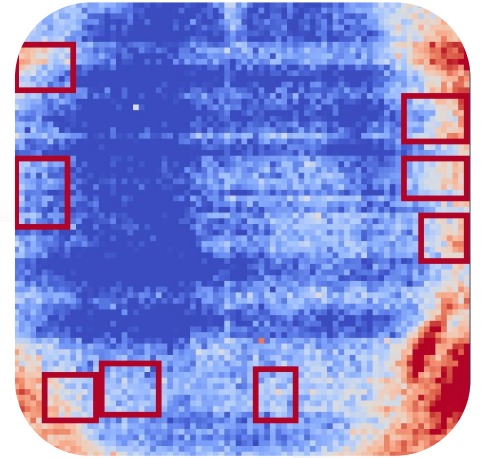
- Due to noise may confuse algorithm and be misclassified





Temperature compensation

- Due to technology constraints camera is very sensitive to ambient temperature
- Beta correction is required to balance individual pixels in different temperatures

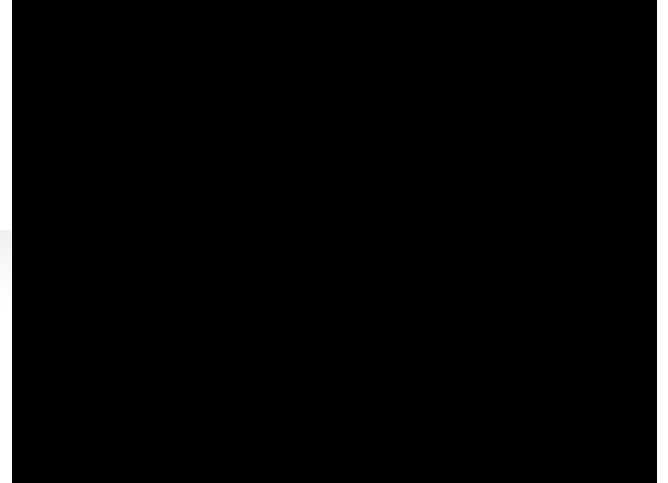
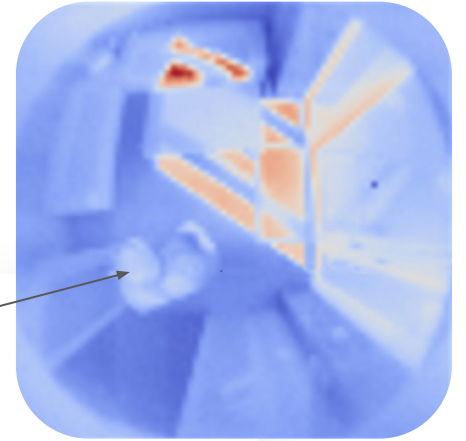




Preheating and false positives

- Heating and cooling systems are impacting device performance
- Laptops, coffee machines, projectors
- Sun impact

Person





Modes of operation – People counting

- 1 frame per minute
- Reports number of people detected
- Reports camera based coordinates

```
Command Prompt
1.004 s 10:06:35.717 -73 ADV_NONCONN d6:87:6a:be:0e:32 {'occupancy': 5, 'occupancy_detection_s': 10, 'positions': [XY(x=59, y=29), XY(x=59, y=68), XY(x=57, y=45), XY(x=27, y=70), XY(x=71, y=19)]}
0.339 s 10:06:23.400 -64 ADV_NONCONN d8:0b:70:c7:8c:08 {'occupancy': 0, 'occupancy_detection_s': 9, 'positions': None}
0.364 s 10:06:35.352 -71 ADV_NONCONN ee:75:78:7d:8f:d8 {'occupancy': 0, 'occupancy_detection_s': 2, 'positions': None}
0.356 s 10:06:34.399 -73 ADV_NONCONN f6:a9:78:23:fb:8a {'occupancy': 0, 'occupancy_detection_s': 4, 'positions': None}
Nothing found... (all scans: 262)
```



Footfall

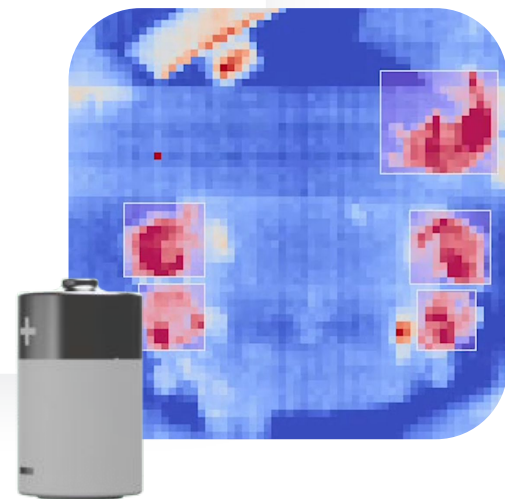
- Counting people walking under the device
- Assigns people to in and out groups

```
Command Prompt
1.001 s 10:33:06.041 -57 ADV e0:bb:cd:f2:ce:03 {'device_model': 'Portal Beam',
'external_power': True,
'firmware': '2.6',
'tx_power': -4,
'type': 2,
'unique_id': '11rU000b'}
7.011 s 10:33:08.271 -57 ADV e0:bb:cd:f2:ce:03 {'Gas resistance': 0,
'Pressure': 64810,
'Temperature': 33.2,
'humidity': 100,
'light_level': 13}
7.011 s 10:33:01.260 -57 ADV e0:bb:cd:f2:ce:03 {'in_out': (6, 6, 348198),
'occupancy': 2,
'occupancy_detection_s': 0}
*** 8.032 s 10:33:09.685 -63 ADV e0:bb:cd:f2:ce:03 {'battery': None,
'channel': 39,
'device_model': 'Portal Beam',
'moving': False,
'room': 3,
'tdiff': -0.549375057220459,
'timestamp': 1648722790.234375,
'tx_power': -4,
'unique_id': u'11rU000b'}
Total 272 Unique 1 (Devices 1) Listed 4
```

Frame rate consideration – power efficiency

How to achieve 4 years battery operation?

- **Occupancy**
 - 1 frame per minute during working hours
 - Longer intervals during off hours
- **Footfall**
 - Not possible 😊
 - Requires external power supply





Processing pipeline

1. Thermal image acquisition
2. Sensor temperature compensation
3. Image denoising
4. Temperature range estimation and normalization
5. Neural network processing with object detection



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