“How to build advanced hand-gestures using radar and tinyML”

Alexander Samuelsson – Imagimob

November 10, 2020
tinyML Talks Sponsors

arm

tinyML Strategic Partner

Deeplite

EDGE IMPULSE

maxim integrated™

Qeexo

Reality AI

SynSense

Additional Sponsorships available – contact Bette@tinyML.org for info
Arm: The Software and Hardware Foundation for tinyML

1. Connect to high-level frameworks
   - Profiling and debugging tooling such as Arm Keil MDK

2. Supported by end-to-end tooling
   - Optimized models for embedded
     - Runtime (e.g. TensorFlow Lite Micro)

3. Connect to Runtime
   - Optimized low-level NN libraries (i.e. CMSIS-NN)
   - RTOS such as Mbed OS
   - Arm Cortex-M CPUs and microNPUs

Stay Connected
- @ArmSoftwareDevelopers
- @ArmSoftwareDev

Resources: developer.arm.com/solutions/machine-learning-on-arm
WE USE AI TO MAKE OTHER AI FASTER, SMALLER AND MORE POWER EFFICIENT

**Automatically compress** SOTA models like MobileNet to <200KB with little to no drop in accuracy for inference on resource-limited MCUs

**Reduce** model optimization trial & error from weeks to days using Deeplite’s **design space exploration**

**Deploy more** models to your device without sacrificing performance or battery life with our **easy-to-use software**

TinyML for all developers

Acquire valuable training data securely

Enrich data and train ML algorithms

Edge Device
Real sensors in real time
Open source SDK

Embedded and edge compute deployment options

Test impulse with real-time device data flows

Get your free account at http://edgeimpulse.com
Health sensors measure PPG and ECG signals critical to understanding vital signs. Signal chain products enable measuring even the most sensitive signals.

The biggest (3MB flash and 1MB SRAM) and the smallest (256KB flash and 96KB SRAM) Cortex M4 microcontrollers enable algorithms and neural networks to run at wearable power levels.

The new MAX78000 implements AI inferences at over 100x lower energy than other embedded options. Now the edge can see and hear like never before.
Qeexo AutoML for Embedded AI
Automated Machine Learning Platform that builds tinyML solutions for the Edge using sensor data

Key Features
- Wide range of ML methods: GBM, XGBoost, Random Forest, Logistic Regression, Decision Tree, SVM, CNN, RNN, CRNN, ANN, Local Outlier Factor, and Isolation Forest
- Easy-to-use interface for labeling, recording, validating, and visualizing time-series sensor data
- On-device inference optimized for low latency, low power consumption, and a small memory footprint
- Supports Arm® Cortex™- M0 to M4 class MCUs
- Automates complex and labor-intensive processes of a typical ML workflow – no coding or ML expertise required!

Target Markets/Applications
- Industrial Predictive Maintenance
- Smart Home
- Wearables
- Automotive
- Mobile
- IoT

QEEXO AUTOML: END-TO-END MACHINE LEARNING PLATFORM

For a limited time, sign up to use Qeexo AutoML at automl.qeexo.com for FREE to bring intelligence to your devices!
is for building products

Reality AI Tools® software

- Automated Feature Exploration and Model Generation
- Bill-of-Materials Optimization
- Automated Data Assessment
- Edge AI / TinyML code for the smallest MCUs

Reality AI solutions

- Automotive sound recognition & localization
- Indoor/outdoor sound event recognition
- RealityCheck™ voice anti-spoofing

https://reality.ai  info@reality.ai  @SensorAI  Reality AI
SynSense (formerly known as aiCTX) builds ultra-low-power (sub-mW) sensing and inference hardware for embedded, mobile and edge devices. We design systems for real-time always-on smart sensing, for audio, vision, bio-signals and more.

https://SynSense.ai
## Next tinyML Talks

<table>
<thead>
<tr>
<th>Date</th>
<th>Presenter</th>
<th>Topic / Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuesday, November 24</td>
<td>Chao Xu</td>
<td>Enabling Neural network at the low power edge: A neural network compiler for</td>
</tr>
<tr>
<td></td>
<td>Vice President of Technology, Eta Compute</td>
<td>hardware constrained embedded system</td>
</tr>
<tr>
<td></td>
<td>Brian Turnquist</td>
<td>Amber: A Complete, ML-Based, Anomaly Detection Pipeline for Microcontrollers</td>
</tr>
<tr>
<td></td>
<td>CTO, Boon Logic</td>
<td></td>
</tr>
</tbody>
</table>

Webcast start time is 8 am Pacific time
Each presentation is approximately 30 minutes in length

Please contact talks@tinyml.org if you are interested in presenting
Free event courtesy of our sponsors – register today!

Full program at [www.tinyml.org/asia2020](http://www.tinyml.org/asia2020)
Live online program daily at 9 am China time

Don’t Miss Next Week!

Premier Sponsor
Additional sponsorships available - contact Bette@tinyml.org for info
Reminders

Slides & Videos will be posted tomorrow

Please use the Q&A window for your questions

tinyml.org/forums  youtube.com/tinyml
Alexander Samuelsson is the CTO and co-founder at Imagimob. Alex has extensive experience of software development in areas such as mobile apps, mobile games and cloud systems. Previously he studied Computer Science at KTH Royal Institute of Technology.
How-to: Advanced gesture recognition using Edge AI and radar

ALEXANDER SAMUELSSON, CTO/CO-FOUNDER
NOV 2020
Introduction to Imagimob

- Specialized in Edge AI (TinyML)
- Experience from 20+ Edge AI customer projects
- We offer
  - Imagimob AI – Software-tools-as-a-Service
  - Edge AI expertise
- Based in Stockholm, Sweden
What I will talk about

- Edge AI according to Imagimob
- Advanced gesture recognition in earphones with Imagimob AI
- Edge AI opportunities for the future
AI at the sensor level

- Where data is collected
- Autonomous
- Real time
- Ultra-low power
- Strong privacy
- We are democratizing Edge AI

According to Imagimob

Imagimob AI
Edge AI | Software-tools-as-a-Service
This is Imagimob AI
Guides and empowers users through the entire Edge AI development process

Create New Project
Collect & Annotate High Quality Data
Manage Data into Different Datasets
Build & Train Great Models
Evaluate and Find the Best Model
Optimize and Package Application

Capture | Studio | Edge

Imagimob AI
Edge AI | Software-tools-as-a-Service
What can you build with Imagimob AI?

Lot's of applications depending on sensors/signals
- Predictive maintenance
- Anomaly detection
- Human activity recognition
- Sound classification/Voice activation
- ...

Radar + Imagimob AI
- Material or surface recognition
- Detect deviations/defects in manufacturing
- Gesture recognition in headphones
Case study – Gesture controlled headphones

- Working proof of concept shown at CES 2020
- Application running in real time on the actual radar module
- ARM-Cortex M4 processor, 256KB RAM shared with BLE stack, firmware, other applications
- Impossible without Edge AI
- Just sending the data off the device would drain the battery and be impossible over Bluetooth
Imagimob Radar gesture software on Acconeer A1 Radar
Challenge #1 – Data collection

Acconeer radar

USB

Laptop with camera

```python
class MySensorConnection(SensorConnection):
    # TODO: Implement all functions in this class

    def __init__(self, *args, **kwargs):
        # Initialize sensor
        pass

    def connect(self) -> None:
        # Connect to sensor
        pass

    def read_data(self) -> np.ndarray:
        # Read a data packet from sensor
        return np.array([1.0, 2.0, 3.0])

    def disconnect(self) -> None:
        # Disconnect from sensor
        pass

    def get_json_packet(self) -> List[dict]:
        # Describe the data format for the Capture App
        return [{"type": "float", "count": 3, "tag": "dummy"}]

# Run the server
sensor_connection = MySensorConnection()
sensor = CaptureSensor(sensor_connection)
sensor.run()
```
Challenge #2 - Preprocessing

Radar output: 30 KB data per second
Model predictions: 14.3 Hz

Learned Preprocessing

Manual preprocessing
- Avg
- Hanning Window
- FFT
- Abs
- Sum
- Sliding Window

Imagimob AI
Edge AI | Software-tools-as-a-Service
Challenge #3 – Testing and verifying

- Testing and verifying Edge AI models is a REAL pain
- To test on device you would have to go all the way to C code
- Moreover you would have to reflash the firmware of your headphones
- To get a really good test we would have to do this on several headphones in different locations multiple times each week
<table>
<thead>
<tr>
<th>Name</th>
<th>Sheet</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch Normalization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convolution 1D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max pooling 1D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch Normalization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How are we different?

- End-to-end
- We have solutions to the major problems
- Data collection
- Model evaluation/testing
- Designed for the Edge all the way
The future (opportunities)
THANK YOU

SIGN UP FOR OUR FREE TRIAL PROGRAM
GET IMAGIMOB AI FOR A FULL MONTH + EDUCATION
LIMITED SEATS

FOLLOW US
@imagimob
@samuelsson_al

WWW.IMAGIMOB.COM
Copyright Notice

This presentation in this publication was presented as a tinyML® Talks webcast. The content reflects the opinion of the author(s) and their respective companies. The inclusion of presentations in this publication does not constitute an endorsement by tinyML Foundation or the sponsors.

There is no copyright protection claimed by this publication. However, each presentation is the work of the authors and their respective companies and may contain copyrighted material. As such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

tinyML is a registered trademark of the tinyML Foundation.

www.tinyML.org