Accelerate Edge AI Creation for a Competitive Edge

SensiML

Bruce Pleat & Chris Knorowski
April 27, 2021
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### AI Virtual Tech Talks Series

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Presenters

Bruce Pleat serves as the Customer Success Manager at SensiML where he is responsible for fostering both new and existing relationships and building long-lasting, customer-centric partnerships. He is a seasoned technology and business professional, and has served in similar roles at both large and small companies including Labelbox, VMware, Wipro, Dow Jones and NASA. He holds an MBA from the University of San Diego and a B.S. in Business from SUNY.

Chris Knorowski is the co-founder and CTO at SensiML where he builds tools to make it easier for developers and engineers to create smart sensor algorithms capable of running at the extreme edge. Prior to SensiML he worked as a software engineer and data scientist at Intel and Dupont Pioneer. He holds a Ph.D in computational physics from Iowa State and a B.S. in Physics from Virginia Tech.
Opportunities: Intersection of AI and Sensing IoT

Health and Wellness
- Aging-in-Place Technology
- Coaching & Rehab Wearables
- Transformative Remote Patient Care

Environmental
- Disaster Prevention & Preparedness
- Data-Driven Resource Conservation

Infrastructure
- Self-Learning Predictive Maintenance
- Ubiquitous Structural Health Monitoring
- Next-Gen AI Process Optimization
Challenges: Implementing AI for IoT at Scale

Cloud-Centric AI
- High Network Traffic Load
- High Latency
- Less Fault Tolerant
- Unknown Risk of Data Security
- Concerns of Privacy

Deep Learning
- Large training data requirements
- Large memory footprint
- High processing workload
- High power consumption
- Poor endpoint battery life

Hand-Coded Endpoints
- Slow and labor intensive
- Unknown code size upfront
- Scarce data science expertise
- Complex AI/ML code libraries
- Not scalable / competitive

```python
import numpy as np # Activation Functions
def tanh(x):
    return np.tanh(x)
def d_tanh(x):
    return 1 - np.square(np.tanh(x))
def sigmoid(x):
    return 1 / (1 + np.exp(-x))
def d_sigmoid(x):
    return (1 - sigmoid(x)) * sigmoid(x) # Loss Functions
    def logloss(y, a):
        return -(y*np.log(a) + (1-y)*np.log(1-a))
    def d_logloss(y, a):
        return (a - y)/(a*(1-a))
```

The layer class
```python
dallols Layer: activationFns = {
    'tanh': (tanh, d_tanh),
    'sigmoid': (sigmoid, d_sigmoid)
}```
SensiML Solves These Challenges:
SensiML Accelerates Edge AI Creation
SensiML: Scalable AI for Intelligent IoT Sensing Applications

- **Autonomous endpoint ML models**
  - Optimized to application specific training data and hardware
  - No cloud processing dependencies
  - Local inferencing provides real-time responsiveness

- **Expansive AI library**
  - Classic machine learning (ML) up through deep learning
  - Auto-optimizer selects best model for the application data provided
  - Models as small as 16KB

- **Hand-coding not required**
  - SensiML auto-generates model code
  - Saves months of development effort, and data science expertise
  - Developer can alter any aspect of the automated code as desired
SensiML: Scalable AI for Intelligent IoT Sensing Applications

- **Physical Sensor(s)**
- **Ultra-Low Power MCU**
- **SensiML AI Model**
- **HW Drivers**
- **User Code**
- **Comms**

**Intelligent Sensing IoT Endpoint**

**Raw Streaming Sensor Data**
- Any time-series sensor type
- One to many channels
- <1 Hz to 100 kHz

**User Application Code**
- Process only on *insightful* events
- SensiML model provide classification, features, or underlying raw data

**Comms**
- Events of value
- bps not Mbps

**Cloud**
- Aggregated processing
- Not raw sensor processing
SensiML Addresses Billions of Time-Series IoT Endpoints

- Smallest processors
- Highly constrained power budgets
- Works without connectivity
- Realtime local insight

Source: IHS 2017

Processor Performance

Power Consumed

- Microwatts
- Milliwatts
- Watts

- 1000+ GOPs
- 10 GOPs
- .1 GOPs

ADAS, VR/AR, Camera Video Object Classification

Visual Inspection and Object Recognition

Industrial IoT Process Control Structural Health Monitoring Vibration Analysis

Motion and Audio Sensing

Source: IHS 2017

Visual Inspection and Object Recognition

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Source: IHS 2017
## Key Markets and Applications

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<td>Smart Home and Consumer Goods Automation</td>
<td>Smart City Infrastructure</td>
<td>Physical Therapy, Outpatient Rehab, and Sports Medicine</td>
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How SensiML Accelerates Edge AI Creation
The SensiML Difference: Production Quality Tools for Real Products

- Complete end-to-end AI workflow
- Comprehensive data collection & labeling
- Optimized Machine Learning Model
- Full code transparency and greatest flexibility
- Built from the ground-up for commercial development teams
- The most comprehensive partner ecosystem and global support network
The SensiML Workflow: Data-Driven Rapid Model Creation

Capture Data

- **SensiML Data Capture Lab**
- **Time:** Hours to Weeks
  (Depending on application data collection complexity)
- **Skill:** Domain Expertise
  (As required to collect and label events of interest)

Build Model

- **SensiML Analytics Studio**
- **Time:** Minutes to Hours
  (Depending on degree of model control exerted)
- **Skill:** None
  (Full AutoML)
  **Basic ML Concepts**
  (Advanced UI tuning)
  **Python Programming**
  (Full pipeline control)

Test Device

- **SensiML TestApp**
- **Time:** Minutes to Weeks
  (Depending on app code integration needs)
- **Skill:** None
  (Binary firmware with auto generated I/O wrapper code)
  **Embedding Programming**
  (Integration of SensiML library or C source with user code)

No Data Science or AI Expertise Required, Prototype Model Testing WithoutCoding
SensiML Data Capture Lab – Better Dataset Collection

- Train/Test Data Collection
- Multi-User Project Collaboration
- Automated Data Management
- Data Labeling & Metadata Annotation
- Synchronized Video Annotation
- Auto Segmentation and Triggering
SensiML Analytics Studio – Better Analysis & Modeling

- Server Based AI Code Generation
- Classic ML to Neural Networks
- Automatic or Directed Model Creation
- Rich Data Visualization and Analysis
- Streamlined User Interface / Experience

SensiML Analytics Studio
SensiML TestApp – Rapid On-Device Model Testing

- Test Tool for Model Validation on Device
- Real-Time and Logged Collection
- Rich Visualizations and Debug Info
- Windows and Android versions
Resulting IoT Endpoint Model: SensiML “Knowledge Pack”

Runtime On-Device Sensor Processing

**Raw Sensor Data**
- Time-series
- Digital or ADC sources
- <1Hz thru 1MHz
- 1 to many channels
- Mixed sensor types

**Signal Pre-Processing**
- Filtering
- Downsampling
- Averaging
- Vector Magnitude
- Scaling
- Normalization

**Event Triggering**
- Threshold
- Sliding window
- Peak Detect

**Feature Transformation**
- Fully automated selection
- Library of 80+ feature transforms
- Option for manual definition / tuning

**Classification**
- Classic ML (SVM, distance, trees)
- Hierarchical models
- Neural Network (TensorFlow Lite)
- Fully automated or manual tuning

**Inference Result**
- Ordinal class value
- Interim feature vector
- Associated raw data buffer
Demo
Most Comprehensive Platform Support and Ecosystem Partners

- QuickLogic
- STMicroelectronics
- NXP
- TensorFlow
- PlatformIO.org
- OPTIMUS LOGIC
- Raspberry Pi
- ARM
- flex
- Arduino
- Nordic Semiconductor
- Shinko Shoji Co., Ltd.
- Silicon Labs
- AVNET
- Future Electronics
- Mostyle Corporation
Predictive Maintenance and Anomaly Detection From Audio and Vibration

Skilled equipment operators are taught to detect and react to machine faults learned through years of experience. With SensiML AI algorithms, this same trained ear wisdom can be applied to 24/7 automated sensor endpoints.

- Slide rails and linear bearings
- Hydraulic / pneumatic valves
- Conveyors and belt/pulley
- Fan and blowers
- Custom equipment
- Custom processes

Inset: Spectrogram of single pump audio sample

High sample rate vibration and microphone sensor stream inputs

Mining operation slurry pressure pump defect enlarged

Inset: Spectrogram of single pump audio sample
Virtual Coaching Wearable Using Real-Time Form and Gait Analysis

• End-to-end toolkit for creating real-time activity and form analysis on-device using SensiML sensor AI

• Gait analysis, form assessment, injury prevention and performance improvement from motion and acoustic, and biosensor classification

• Fully autonomous AI processing and insight, no cloud or smartphone needed

• Available, richly annotated, licensable datasets for selected applications including running, weightlifting, racket sports, and football

Treadmill running protocol gait measurement for single channel of twelve total 9DoF sensors captured in SensiML virtual running coach model
Wellness Screening with Endpoint AI Time-Series Sensor Processing

Overview

Transform raw signal data from bio, acoustic, and environmental sensors to provide real-time inference and wellness classification using AutoML techniques.

SensiML Analytics Toolkit can rapidly construct classification models from multiple sensor inputs including:

• Core body temperature trending
• Optical PPG reflection-type pulse / HRM sensors
• VoC gas sensors
• Microphone / acoustic measurement
• Galvanic skin response
• Force / load cell (body weight) trending
• Motion from multi-axis IMU sensors

Proven SensiML Health/Wellness Applications

• Acoustic respiratory cough classification
• NFC temperature patch health classifier
• Wellness / fitness wristband wearables
• First responder status / health wearable
• Gait analysis / fall detection
Smart Raised Pavement Markers Enable Safer Roadways

Overview

There are few items more pervasive than the ordinary raised pavement marker (RPM). Consider the possibilities when this simple passive safety device is transformed into a smart IoT active safety device with the following capabilities:

- Multi-axis vibration sensor
- Microphone
- Ultra low-power ML-capable microcontroller
- Adaptive high power RGB LED
- Wireless connectivity
- Solar charging and battery charging circuitry
- AI pattern recognition algorithm powered by SensiML

https://datadepot.sensiml.com/datasets/smart-road-sensor
To Learn More...

Please contact:
Bruce Pleat at bruce.pleat@sensiml.com
http://linkedin.com/in/bpleat
https://sensiml.com/contact

Please sign up for a FREE Community Edition account:

https://sensiml.com/armgiveaway
Thank you for joining!

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Check out our Arm Software Developers YouTube channel

Signup now for our next AI Virtual Tech Talk here

Attendees: don’t forget to fill out the survey to be in with a chance of winning an Arduino Nano 33 BLE board
Thank You
Danke
Merci
谢谢
ありがとう
Gracias
Kiitos
감사합니다
धन्यवाद
 شكرا
תודה