“Oculi is putting the human eye in A.I.”

Charbel Rizk – Founder, CEO, CTO of Oculi Inc.

January 25, 2022
tinyML Talks Strategic Partners

Additional Sponsorships available – contact Olga@tinyML.org for info
Executive Strategic Partners
Arm: The Software and Hardware Foundation for tinyML

1. Connect to high-level frameworks
2. Supported by end-to-end tooling
3. Connect to Runtime

- Application
- Optimized models for embedded
- Runtime (e.g. TensorFlow Lite Micro)
- 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
The leading edge ML platform

www.edgeimpulse.com
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

**Perception**
- Object detection, speech recognition, contextual fusion

**Reasoning**
- Scene understanding, language understanding, behavior prediction

**Action**
- Reinforcement learning for decision making

A platform to scale AI across the industry
SYNTIANT

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

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

partners@syntiant.com
www.syntiant.com
Platinum Strategic Partners
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

BECOME BETA USER bit.ly/testdeeplite
**Reality AI**

Add Advanced Sensing to your Product with Edge AI / TinyML

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

**Reality AI solutions**
- Prebuilt sound recognition models for 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

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https://reality.ai  info@reality.ai  @SensorAI  Reality AI
# Broad and Scalable Edge Computing Portfolio

## Microcontrollers & Microprocessors

<table>
<thead>
<tr>
<th>Arm® Core</th>
<th>Renesas Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm® Cortex®-M 32-bit MCUs</td>
<td>Ultra-low Energy 8 &amp; 16-bit MCUs</td>
</tr>
<tr>
<td>Arm ecosystem, Advanced security, Intelligent IoT</td>
<td>Bluetooth® Low Energy, SubGHz, LoRa®-based Solutions</td>
</tr>
<tr>
<td>Arm®-based High-end 32 &amp; 64-bit MPUs</td>
<td>High Power Efficiently 32-bit MCUs</td>
</tr>
<tr>
<td>High-resolution HMI, Industrial network &amp; real-time control</td>
<td>Motor control, Capacitive touch, Functional safety, GUI</td>
</tr>
<tr>
<td>Arm® Cortex®-M0+ Ultra-low Power 32-bit MCUs</td>
<td>40nm/28nm process Automotive 32-bit MCUs</td>
</tr>
<tr>
<td>Innovative process tech (SOTB), Energy harvesting</td>
<td>Rich functional safety and embedded security features</td>
</tr>
</tbody>
</table>

**Renesas Synergy™**
- Arm®-based 32-bit MCUs for Qualified Platform
- Qualified software and tools

## 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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Gold Strategic Partners
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
LatentAI

Adaptive AI for the Intelligent Edge

Latentai.com
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
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
Silver Strategic Partners
tinyML Summit 2022
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 February 28.

tinyML Research Symposium 2022
March 28, 2022
https://www.tinyml.org/event/research-symposium-2022

More sponsorships are available: sponsorships@tinyML.org
tinyML Trailblazers Series
Success Stories with Joel Rubino
(CEO & Co-founder of Cartesiam)

LIVE ONLINE February 2nd, 2022 at 8 am PST

Register now!
Join Growing tinyML Communities:

**Meetup**
7.8k members in
42 Groups in 33 Countries

**tinyML - Enabling ultra-low Power ML at the Edge**

**LinkedIn**
2.5k members &
4.4k followers

**The tinyML Community**
https://www.linkedin.com/groups/13694488/
Subscribe to tinyML YouTube Channel for updates and notifications (including this video)
www.youtube.com/tinyML
Next tinyML Talks

<table>
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<tr>
<th>Date</th>
<th>Presenter</th>
<th>Topic / Title</th>
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<tbody>
<tr>
<td>Tuesday, February 1</td>
<td>Muhammad Shafique, New York University Abu Dhabi (NYUAD), UAE</td>
<td>Energy-Efficiency and Security for TinyML and EdgeAI: A Cross-Layer Approach</td>
</tr>
</tbody>
</table>

Webcast start time is 8:00 am Pacific time

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

Slides & Videos will be posted tomorrow

tinyml.org/forums  youtube.com/tinyml

Please use the Q&A window for your questions
Dr. Rizk is the Founder CEO, CTO of Oculi and an Associate Research Professor at Johns Hopkins ECE. He has been recognized as a top innovator, thought leader, and successful Principal Investigator / S&T manager. He was a pioneer in autonomous systems and led a small team that developed and demonstrated the first four-rotor (quad rotor) UAV system in the early 90's. Dr. Rizk has successfully collaborated with various FFRDC's, government labs, academia, and industry of various sizes. He is a senior member of IEEE, AIAA, and a member of AUVSI, EAA, and OSA.
• **OCULI SPU** is the *only* software-defined vision sensor on a single-chip
  - Combines sensing + pre-processing at the pixel to deliver real-time vision intelligence

• **Up to 30x better in energy-delay product**
  - The most efficient architecture whether constrained by power, latency, processing, or bandwidth

• **Proven technology** with well protected IP
  - Functioning chips that have been delivered to partners for evaluation

• **Initial focus on XR and smart/interactive display (B2B)**
  - Can easily expand to other markets such as ITS, industrial, and automotive
# Oculi Mimics Human Vision

<table>
<thead>
<tr>
<th>Sense</th>
<th>Transfer</th>
<th>Perceive</th>
<th>Act</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Machine Vision</strong></td>
<td>2MP</td>
<td>2 Gb/s</td>
<td>W's 0.4-1 sec</td>
</tr>
<tr>
<td><strong>Human Vision</strong></td>
<td>Vision Intelligence</td>
<td>10 Mb/s</td>
<td>mW's 13 ms</td>
</tr>
<tr>
<td><strong>Oculi Vision</strong></td>
<td>Vision Intelligence</td>
<td>kb/s - 2 Gb/s</td>
<td>mW's 1 ms</td>
</tr>
</tbody>
</table>
SPU = Sensing and processing unit

OCULI SPU ARCHITECTURE

- Integrated neuromorphic sensing & processing
- Intellipixel = sensor+processing+memory
- Sensor Agnostic: works with conventional CMOS, DVS, infrared, depth/TOF, and multi-mode

Oculi Outputs
- Full Frames
- Events
- Smart Events
- Actionable Information

OCULI SPU

Scene

Intellipixel

Patented digital pixel, processing and memory architecture
The OCULI SPU is dynamically programmed to deliver the signal of interest.

- **30% bandwidth**
  - GB/s
- **3% bandwidth**
  - MB/s
- **0.001% bandwidth**
  - KB/s

**Full frame**
- 26-bit grayscale intensity value on all pixels

**Events**
- -1 | 0 | +1
- Positive or negative spike on events

**Smart Events**
- 26-bit grayscale intensity value on events

**Billable Events**
- <metadata>
  - In this case: Axle detected

Customer validation with OCULI SPU S11 – first Oculi product
A complete vision solution on a single chip, ideal for edge applications

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SINGLE CHIP SOFTWARE-DEFINED VISION SENSOR

- All key aspects are programmable to enable dynamic optimization
  - Native raw output: full frame, events, smart events, and actionable signal
  - Smart selectivity including spatial and temporal filtering
  - Sampling speed: Hz to MHz
  - In-pixel memory & compute
  - Sensitivity
  - Dynamic range
  - Quantization level
  - Bit depth and resolution
  - Sensing modality: color, depth, or both
OPTIMIZED SYSTEM/SOLUTION ARCHITECTURE

OCULI SPU™

Information
Pixel-level Fusion

Action

Central Processor
Systems, Control, and Management Planning

Continuous optimization
For speed, areas of interest, weather, lighting and other factors

Parallel sensing + processing
Saliency/Feature output
Bi-directional communication

Photons
KEY VISION TRADE OFF: LATENCY (or BANDWIDTH) VS. POWER

Software-defined architecture delivers flexibility to operate and optimize in this trade space, enables economies of scale – same hardware product for multiple markets.

Oculi technology enables solutions for lowest latency*, lowest power*, and/or bandwidth*.

*When cost is the common denominator
INTELLIPIXEL REDUCES SYSTEM LATENCY & POWER

**OCULI SPU**

Pixel Ops:
- N A/D conversions
- N 1-bit multiplication & comp

| 1 | × | 1 | = | 1 |

Readout/transfer

BW reduction * N bits

External Memory + Processor

None

---

**Binary Sensor with N pixels**

Sensor

N times charge transfer to array edge

Electric Charge

N A/D conversions

1,1

N 1-bit multiplication & comp

N bits

1,1

1

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Z = A */ Y ± B

A & B are also programmable per pixel

---

EFFICIENT REAL-TIME GESTURE, EYE, & FACE TRACKING

- Gesture Control
- High speed depth sensing with stereo vision
- A complete vision solution on a single chip
- Delivers near-zero lag & anonymous user analytics

Eye Tracking

Face Detection
ML Model was trained on full frames and used as is, no additional fine tuning
ML Model evaluated using smart events as the input data (native raw output of the OCULI SPU)
PEOPLE COUNTING: SMART EVENTS VERSUS FULL FRAME

• ML Model was trained on full frames and used as is, no additional fine tuning
• ML Model evaluated using smart events as the input data (native raw output of the OCULI SPU)

<table>
<thead>
<tr>
<th></th>
<th>Full Frame</th>
<th>Smart Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth:</td>
<td>100.00%</td>
<td>1.91%</td>
</tr>
</tbody>
</table>

![Graph showing comparison between Full Frame and Smart Events]

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The OCULI SPU reduces bandwidth and external processing by up to 99% with zero loss of relevant data making it ideal for IoT and Edge Applications.
REAL TIME SPATIAL FILTERING WITH ANY PATTERN
OCULI REMOVES THE SENSOR THROUGHPUT/BANDWIDTH/DATA CONSTRAINTS

Full Frame (120 GB/s)  Smart Events (10 MB/s)  Actionable Signal (30 kB/s)

Oculi Technology Enables EFFECTIVE TinyML Solutions Even for High Speed Imaging Applications
Smart Events based on rate of change

Smart Events based on value

In-pixel Sensor Fusion & Smart Selectivity Enables TinyML Solutions for 3D Imaging Applications
USER FRIENDLY PLATFORM & SOFTWARE TOOLKIT

- Interactive GUI
- Interfaces with S11 SPU

Oculi P11/P11B Platform
- Shipped to customers
- Used for all demos and pilot projects
- Includes S11 SPU

Stereo Vision platform available Q1 2022
- Includes S11 SPU (x2)

GUI
Interactive GUI to collect data and visualize output from the OCULI SPU™ in various modes.

DEMOS
Comprehensive, out of the box demo applications including:
- Visualize: differencing, foreground extraction, intensity mode, full frames
- Scene reconstruction
- Anonymous face detection

SDK
Libraries (C++), code samples (C++/Python), and documentation.
OCULI SPU and other Oculi products referenced herein are products of FRIS Inc. (dba Oculi).

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OCULI SPU™
BionicVision®
LiDAR Lite™
Software-Defined Vision Sensor™
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For additional information please contact charbel.rizk@oculi.ai
REAL-TIME VISION INTELLIGENCE

- LOW POWER
- LOW BANDWIDTH
- LOW COST
- FAST RESPONSE
- SMALL / LIGHT WEIGHT

Charbel Rizk PhD, Founder CEO
charbel.rizk@oculi.ai

THANK YOU!

www.oculi.ai
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