Reality AI®

A Renesas Company

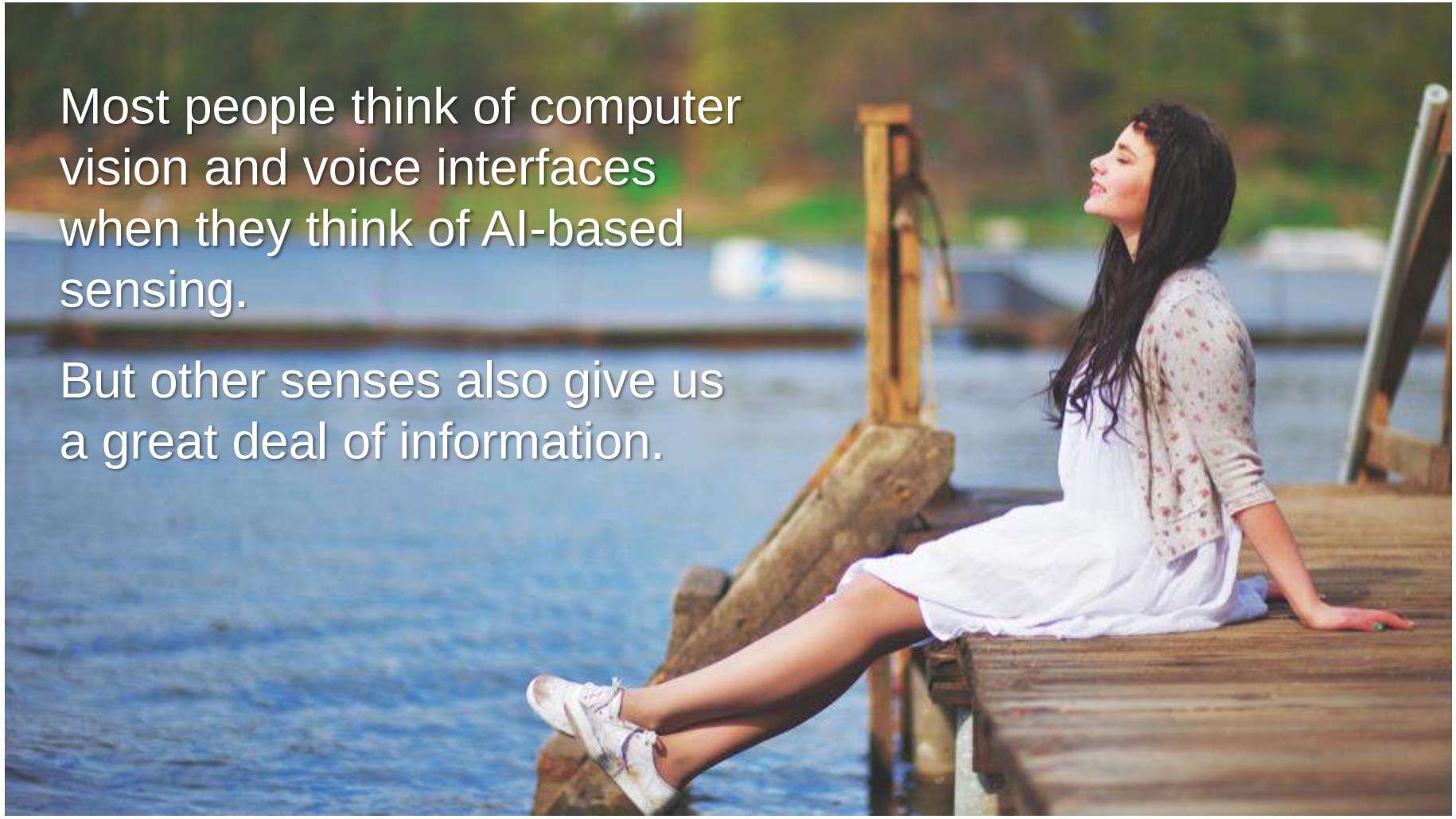
IIBU SALES TRAINING

REALITY AI : EMBEDDED MACHINE LEARNING FOR REAL-TIME ANALYTICS ON RENESAS MCUS

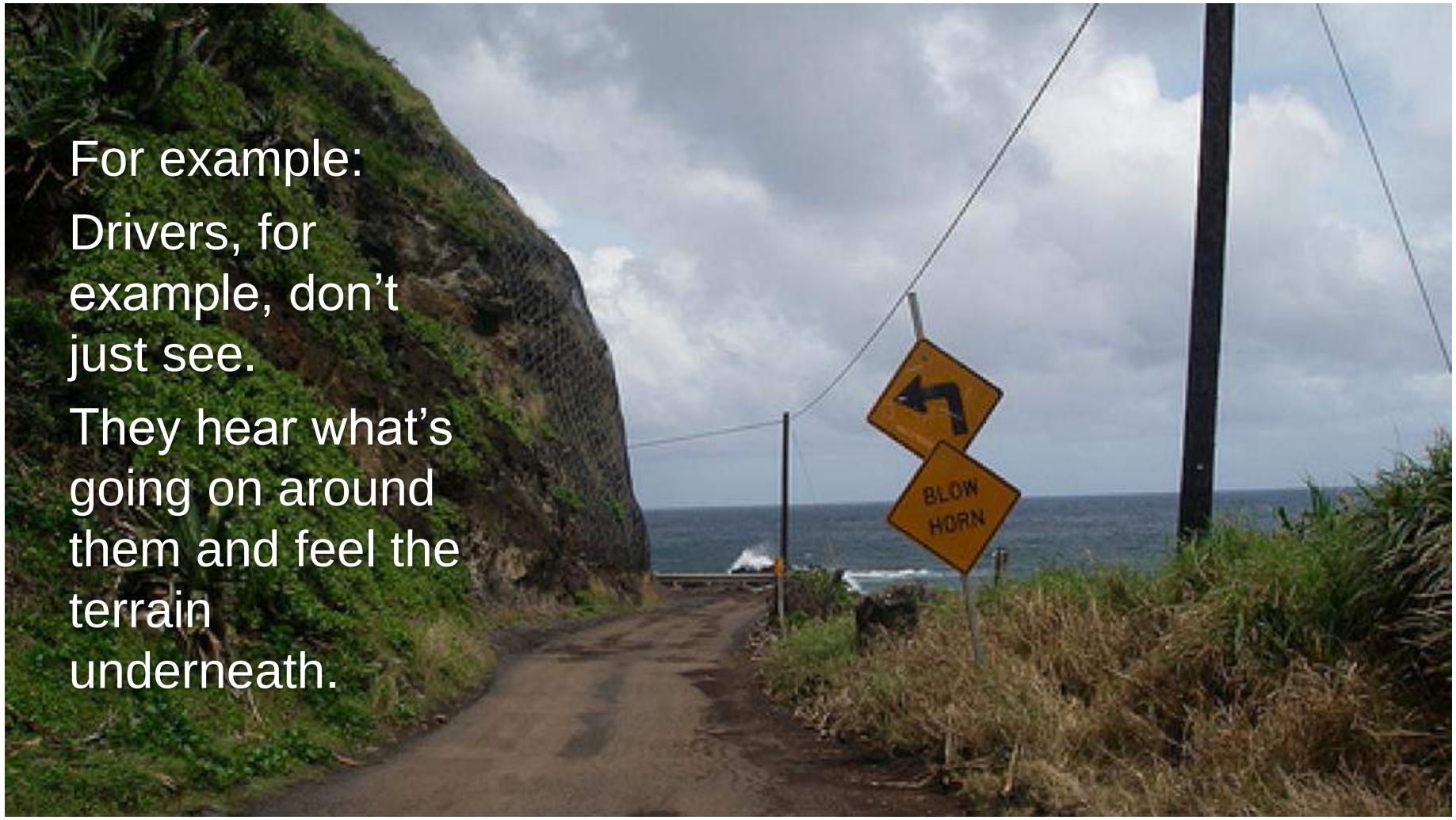
JANUARY 2023

RENESAS ELECTRONICS CORPORATION

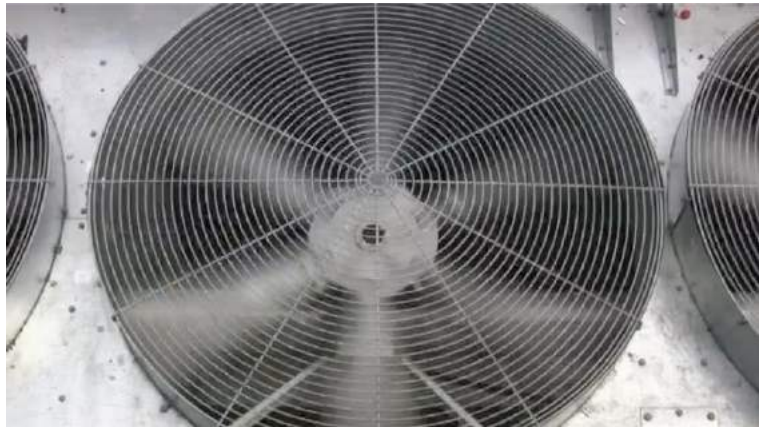
THERE IS MORE TO SENSING THAN VOICE AND VISION



SOUND AND VIBRATION GIVE IMPORTANT CONTEXT

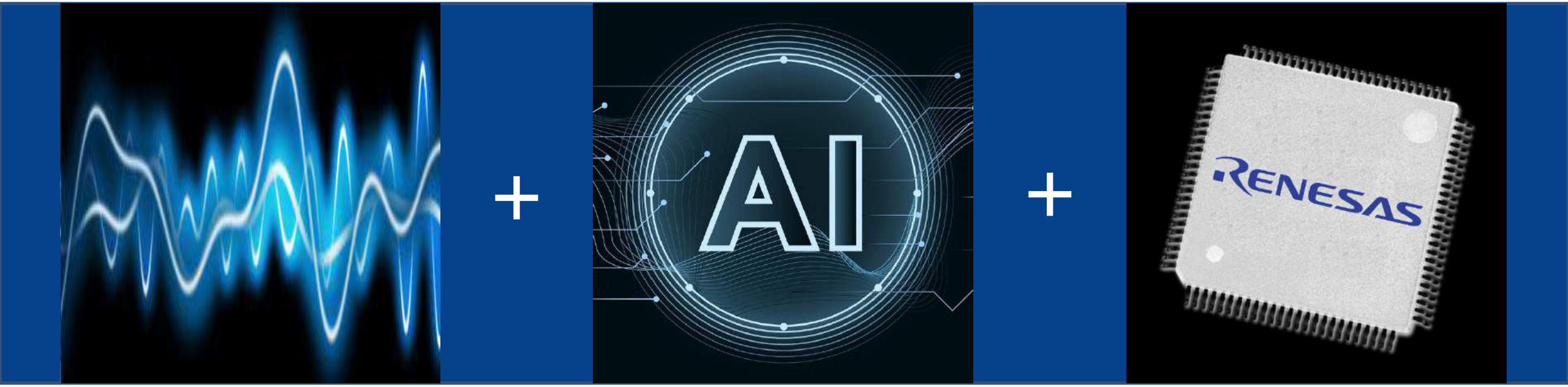


IN MACHINES, NON-VISUAL SENSING CAN TELL US A LOT



Vibration, sound, current, voltage, and RF signals can all be used to determine the condition of specific components, predict their maintenance needs, and forecast time-to-failure or remaining-useful-life.

REALITY AI COMBINES ADVANCED SIGNAL PROCESSING AND MACHINE LEARNING ON MCU / MPU EDGE NODES



Advanced Signal Processing

Reality AI automatically searches a wide range of signal-processing transforms to create a custom, optimized feature transform.

Artificial Intelligence and Anomaly Detection

Reality AI automatically generates machine learning models, explanatory visualizations, and hardware design analytics.

MCU / MPU Edge Nodes

Reality AI runs on almost every MCU and MPU core available from Renesas, with new ones added constantly. Reality AI also supports Renesas Motor Control boards.

SCALABLE FROM 16-BIT TO 64-BIT CORES

REALITY AI SOFTWARE ADDRESSES COMMON ENGINEERING FRUSTRATIONS WITH AI / ML

Engineers' frustrations with AI / ML:

Mostly use AI for difficult problems, where traditional methods aren't working and there are **no obvious solutions**.
Instrumentation and hardware issues add complexity. Must optimize for **cost**.
Can not deploy **"black box"** solutions.

How Reality AI makes it better:

Built specifically for **non-visual sensing based on advanced signal processing** math and edge deployment on Renesas MCUs.
Analytics to support hardware design (not just algorithms and model building).
Explainability based on time-frequency characteristics, with full transparency.

REALITY AI OFFERS BOTH SOFTWARE AND SOLUTIONS

Reality AI Software

Reality AI Tools®
Build models, visualize explanations, optimize hardware build

RealityCheck AD
Add-on to Reality AI Tools for factory applications

RealityCheck MOTOR *(coming soon – now in early customer beta)*
Add-on to Reality AI Tools for Renesas motor control boards

Software for model creation and hardware optimization on Renesas MCUs, MPUs and motor control kits.

Reality AI Solutions

RealityCheck HVAC *(coming soon – now engaging with early customers)*
Complete framework for smart, self-diagnosing HVAC

Automotive SWS
Complete framework for audio-based ADAS sensing for vehicles

Complete frameworks for specific use cases, including hardware, firmware, software and ML reference designs.

INDUSTRIAL AND IOT APPLICATIONS

There are non-visual sensing applications in all kinds of electro-mechanical products, for example:

Air conditioners that predict their own maintenance needs

Mining equipment that knows when contaminants require a shutdown.

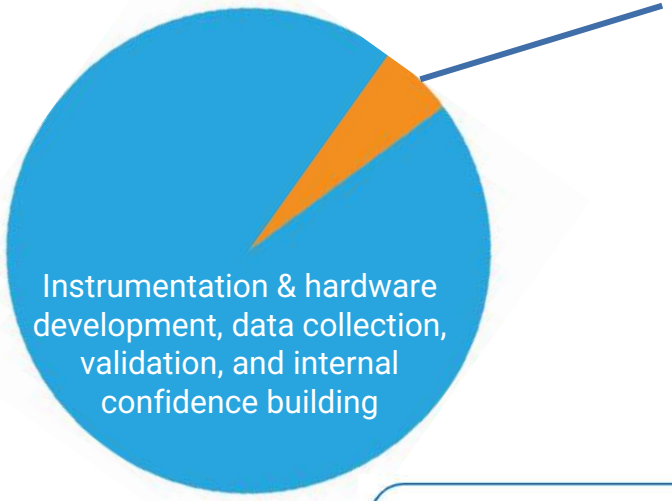
Diagnose the source of power quality issues based on 3-phase AC

Electric motors that monitor the health of the systems they drive.

Pumps that know when they are dry or cavitating.

Filters that know how long till they will clog.

REALITY AI ADDRESSES THE FULL AI-IOT DESIGN LIFECYCLE



Only 5% of typical project costs are spent on building models

Reality AI Tools®

software helps with the other 95% too

RealityAI Tools® software

- AI Explore™ (AutoML)
- Sensor Selection and BOM Optimization
- Data Readiness
- Edge AI / TinyML Code Optimization
- Optional Add-ons: RealityCheck AD, RealityCheck MOTOR, Reality AI for MATLAB

Algorithmically-Driven Feature Discovery

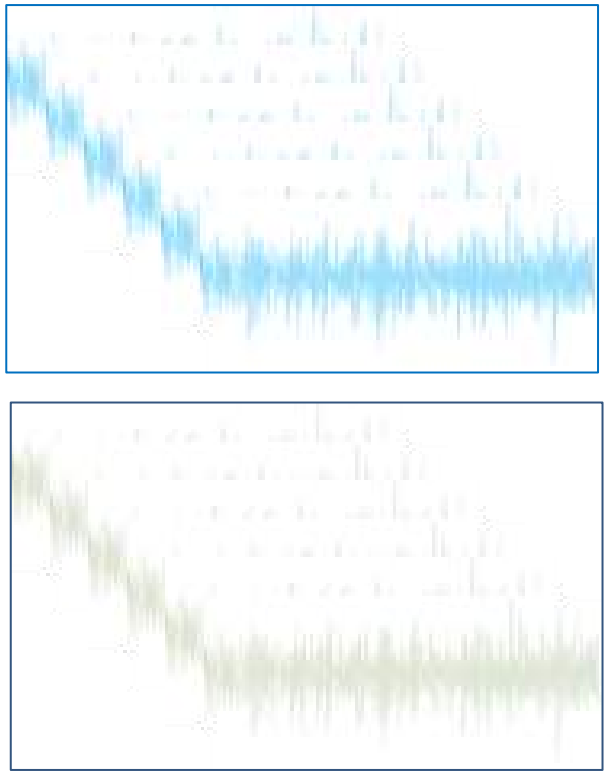
REALITY AI TOOLS IS A DEV ENVIRONMENT FOR EMBEDDED, NON-VISUAL SENSING

Four key features of Reality AI Tools:

1. AutoML – automatic generation of ML model based on signal data
2. TinyML / Edge AI optimization
3. Hardware design analytics
4. Other features

A DEV ENVIRONMENT FOR EMBEDDED, NON-VISUAL SENSING

1. AutoML – automatic generation of ML model based on signal data



Examples of “A”

Examples of “B”

Reality AI Tools®

Generated ML Code

- Compiled for MCU target
- C / C++
- MATLAB

A DEV ENVIRONMENT FOR EMBEDDED, NON-VISUAL SENSING

2. TinyML / Edge AI Optimization

- AutoML algorithm
  - Generates optimized feature computations, as well as ML model
  - When exported, models can use hardware-based signal processing acceleration
- Feature optimizations
  - Based on advanced signal processing math guided by proprietary algorithm
  - Ensures greatest accuracy for smallest resource footprint.
- Can compile for specific MCU/MPU targets or take source code and optimize by hand.
- Many customer models require only kBs of RAM, but this is highly application-specific.

A DEV ENVIRONMENT FOR EMBEDDED, NON-VISUAL SENSING

3. Hardware design analytics – more than just making ML models

Best Sensors / Channels / Locations
Automatically determine the best combination of sensors and sensor locations.

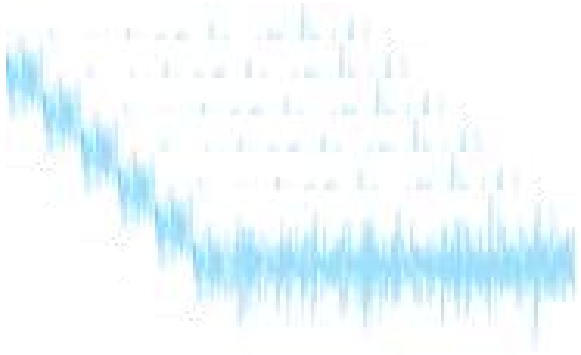
Generate Component Specifications
Evaluate minimum sample rate, bit depth and measurement tolerance for sensor components.

Processor Requirements
Examine RAM and flash requirements for each model, as well as multiplies required for feature and ML model computations.

Noise Sensitivity
Simulate model performance in the presence of noise, and how that performance interacts with component specs for sensors.

A DEV ENVIRONMENT FOR EMBEDDED, NON-VISUAL SENSING

Reality AI uses extensive computational power in the cloud to generate ML code for embedded sensing



High-frequency sensor data

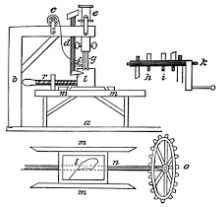
- Vibration
- Sound
- Electrical
- RF

Reality AI Tools software

- Cloud-based
- AutoML
- Data analytics

Embedded Machine Learning Code

- Source code or compiled
- Ready to incorporate in IDE project



Design analytics

- Sensor selection and placement
- Minimum component specs
- Model sensitivity and tolerances

RealityCheck MOTOR

- Forthcoming add-on to Reality AI Tools® software for deploying ML models to Renesas motor control kits.
- Initial proof-of-concept complete and integration underway.
- Currently available in early beta (with some functionality not yet fully automated)

Enables sensorless ML models to be deployed directly to the motor control board:

- Uses electrical information already available on the board
- Takes high sample-rate current and voltage as a proxy extra components (like accelerometers)
- Deploys models back to E2Studio, where they can be optimized for simultaneous operation alongside motor control algorithms

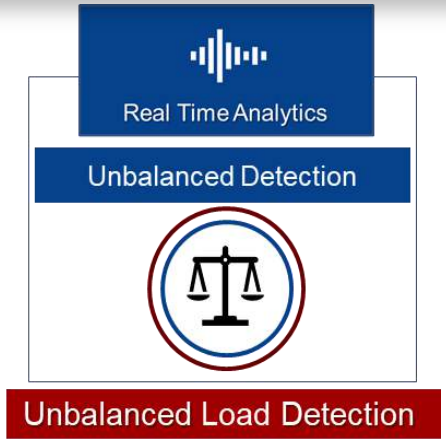
For embedded predictive maintenance, anomaly detection and control feedback in electric motor-driven systems.

REALITYCHECK MOTOR – POC DEMONSTRATION

Reality AI
A Renesas Company

Demo Video: https://vimeo.com/706307648/e4e2c73a7f

AI/ML Unbalanced Load Detection + Sensor-less FOC



NO ADDITIONAL SENSORS!
Leverages Available Electrical & Motor Signals

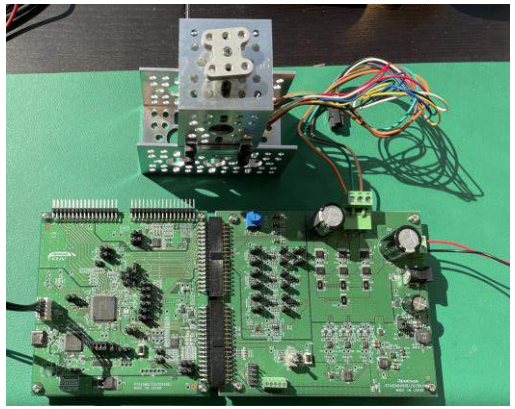
Operates Across Variable PWM Frequencies & Motor Speeds

FLASH	RAM	Inference Time
20KB	9KB	~3.5ms

Accuracy >90%

RA6T2 – ARM® Cortex® M33 at 240MHz

Renesas AI/ML Reference H/W



- MCK-RA6T2 Kit
- MCU RA6T2 – 240MHz M33
- PMOD / UART
- USB Serial Terminal
- CAN I/F
- BLDC / PMSM 3-Shunt Sensor-less FOC
- LV 3-Phase Inverter (48V/10A)

RealityCheck HVAC

Using machine learning and edge processing, it is now possible to build HVAC units with the native ability to detect a wide range of faults and operating conditions.

Target Conditions for Detection / Prediction

- Blocked indoor/outdoor airflow
- Coil frosting
- Refrigerant charge issues - undercharge / overcharge
- Faulty fan
- Faulty compressor
- Failing capacitor
- Heating / cooling capacity reduction
- Filter life prediction
- Other conditions

Initial lab PoC using a 3-ton residential outdoor unit from a US maker (demo video coming) has shown:

- >95% accuracy in detecting and distinguishing single fault conditions
- Covered indoor and outdoor air-flow blockage and charge faults as small at 5% from OEM specifications
- Both heating and cooling modes
- Tested under 51 different environmental and load conditions

RealityCheck HVAC