

tinyML[®] Summit

Enabling Ultra-low Power Machine Learning at the Edge

**PRODUCTS AND APPLICATIONS
ENABLED BY TINYML**

March 28 – 29, 2023



www.tinyML.org

Designing Multi-Modal Smart HMI

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NXP
MARCH 2023

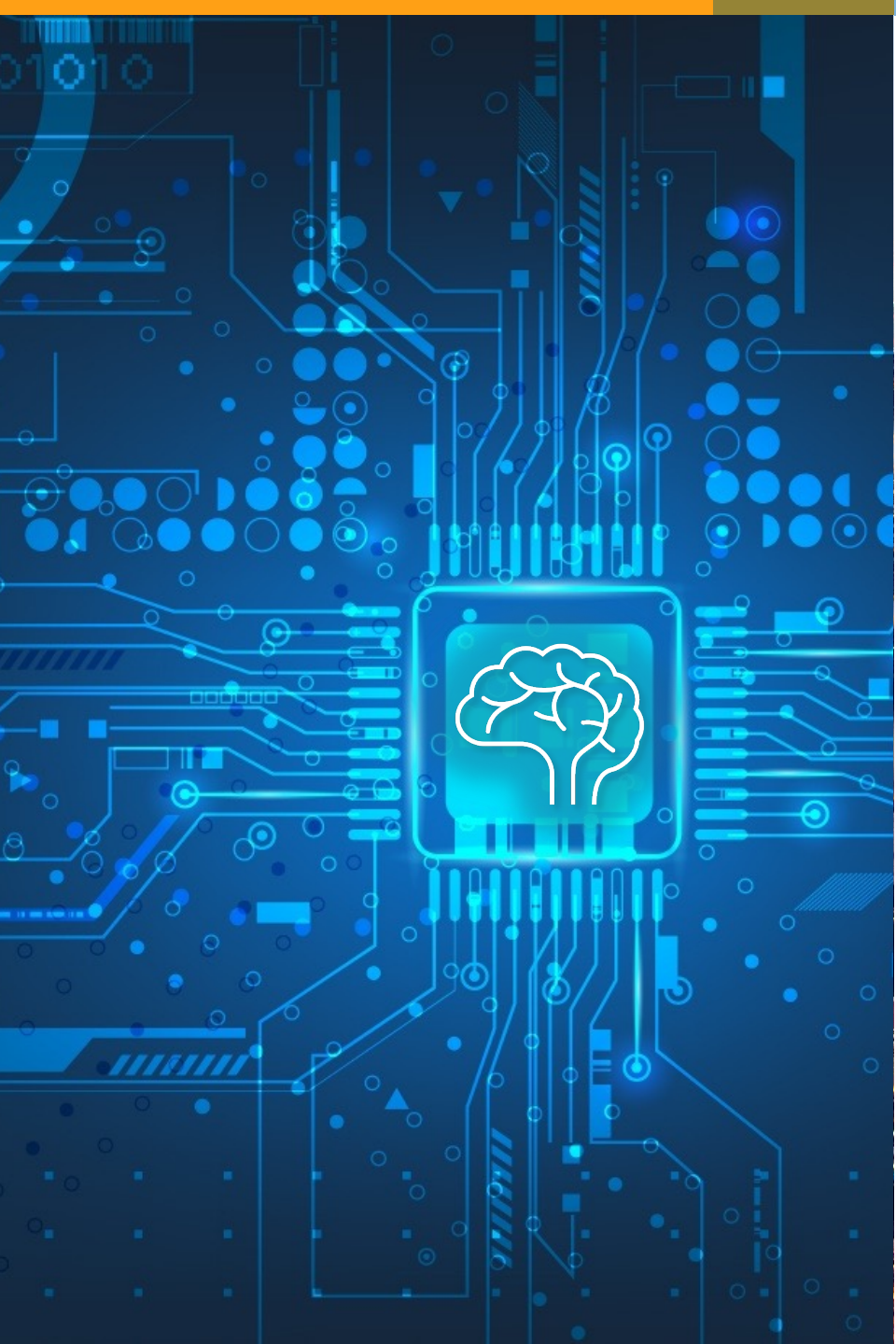


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AGENDA

Introduction

Requirements for Smart HMI

NXP Edge-Ready Smart HMI Solution

Summary

Introduction



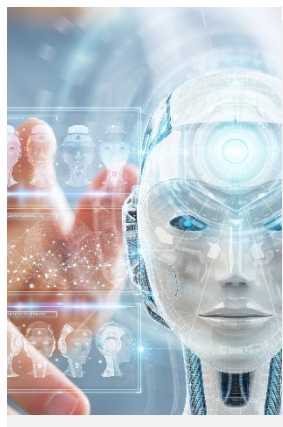
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NXP BROAD-BASED MACHINE LEARNING SOLUTIONS AND SUPPORT



eIQ Machine Learning SW

eIQ® ML SW Development Environment

eIQ Toolkit with eIQ Portal GUI to:

- Import/create, convert, optimize, validate and deploy ML models
- Dataset curation tools to create new, augment, label/annotate datasets

eIQ inference with:

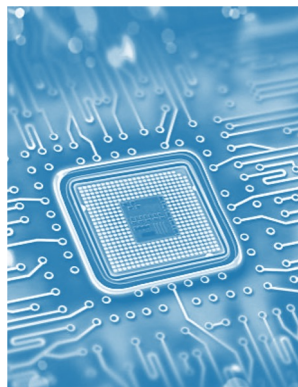
- TensorFlow Lite, TensorFlow Lite Micro and DeepViewRT

eIQ Marketplace:

- Add-on wares available from eco-system partners and NXP for ML applications, optimized models, optimization tools, datasets and sensor solutions

Support for i.MX 8M, i.MX 9, i.MX RT, MCX family of devices

Integrated with NXP dev environments (MCUXpresso, Yocto/Linux)



NXP eIQ Neutron NPU

NXP eIQ Neutron NPU

- Highly scalable ML acceleration cores
- Unified architecture and software support
- Optimized for edge performance and power dissipation



SLN-TLHMI-IOT-RD

Voice and Turnkey Solutions

Conversa, VoiceSeeker, VoiceSpot and Voice Intelligent Technology (VIT)

- Voice control and communications solutions for human-to-human and human-to-machine voice applications

Smart HMI solution

- i.MX RT117H (kit - SLN-TLHMI-IOT-RD)

Face & emotion recognition solution with Anti-Spoofing

- i.MX RT106F (kit – SLN-VIZN-IOT)

Local voice control solution

- i.MX RT106L (kit – SLN-LOCAL-IOT)



AuZone Vision Kit Micro (i.MX RT1064)

Third Party SW and HW

- Cloud ML lifecycle and analytics services integration with Hyper Scaler (AWS, Azure,)
- HW and SW packages integrated with NXP eIQ Toolkit as extensions or through eIQ Marketplace
- External accelerator integrated solutions

TARGET APPLICATIONS-SMART HMI SOLUTION

Smart HMI Applications

Smart Appliances

- White goods
- Counter-top (e.g., coffee machine, purifier, etc.)

Smart Home

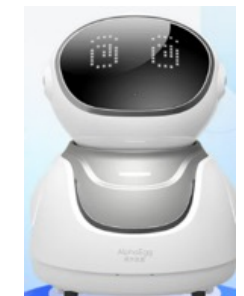
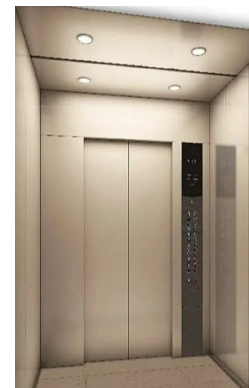
- Alarm and smart home control panels
- Thermostats
- Universal remote controls
- Home entertainment

Smart Building, Smart Industrial

- Elevator
- Garage door openers and access panels
- Industrial HMI
- Healthcare
- Transportation

Others

- Remote conference control
- Personal health care



REQUIREMENTS OF SMART HMI

High-Performance

Rich, interactive display and content, 2D Graphics

Smart Interactions

Provide active services and access control that anticipate their users' needs

Intuitive Interfaces

Friction-free user experience through face, gesture, & voice



Feature-Rich Yet Simple

High integration to enable more functions with simple design

Low Latency, Low Power

ML vision & voice are performed entirely offline; lower power consumption and faster boot time than MPU based solutions

Connectivity

Wi-Fi/Bluetooth, MATTER

Design Challenges:

- Implementing & incorporating ML/AI has a high initial investment and barrier to entry
- Developing feature-rich HMI applications can be complex and expensive

Smart HMI Solution



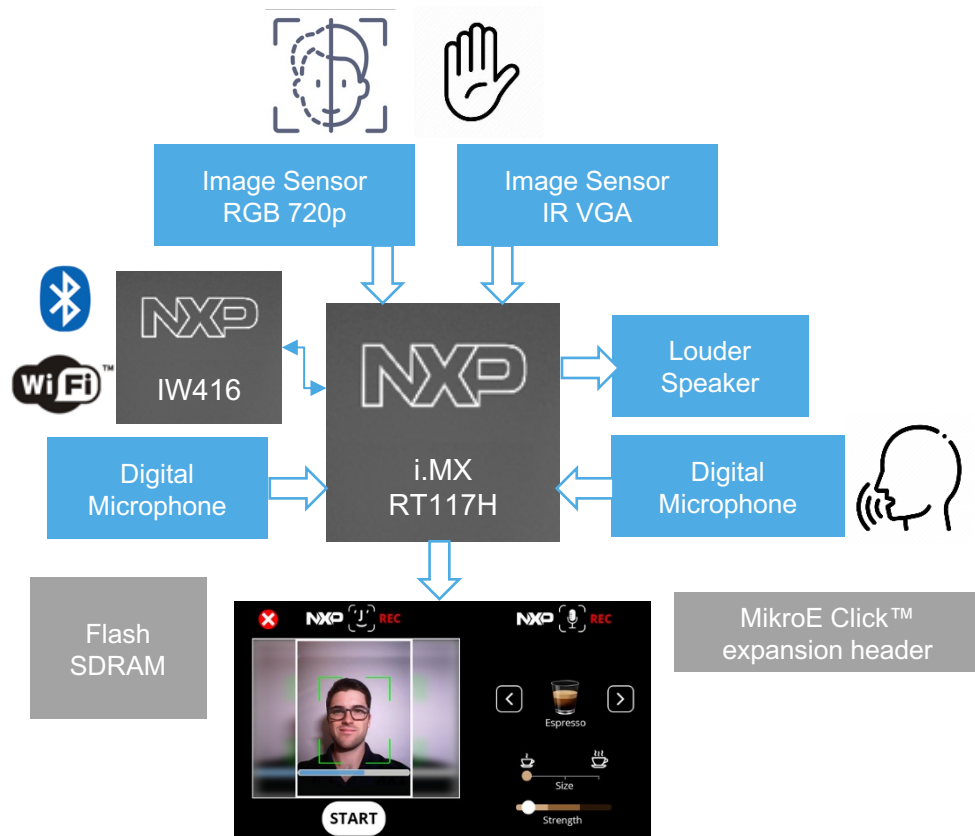
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SMART HMI-EXPANDING CAPABILITIES WHILE SIMPLIFYING SYSTEM DESIGN



Smart HMI Solution Capabilities

Graphics Display User Interface

- 5.5-inch 720P MIPI LCD display
- LVGL and VGLite 2D graphics accelerator support
- Coffee Machine, Elevator, and Smart Home Panel out-of-box demos available

Machine Vision

- 720p RGB and VGA IR Image Sensors
- Supports user identification via face recognition
- Supports gesture control via palm shape recognition

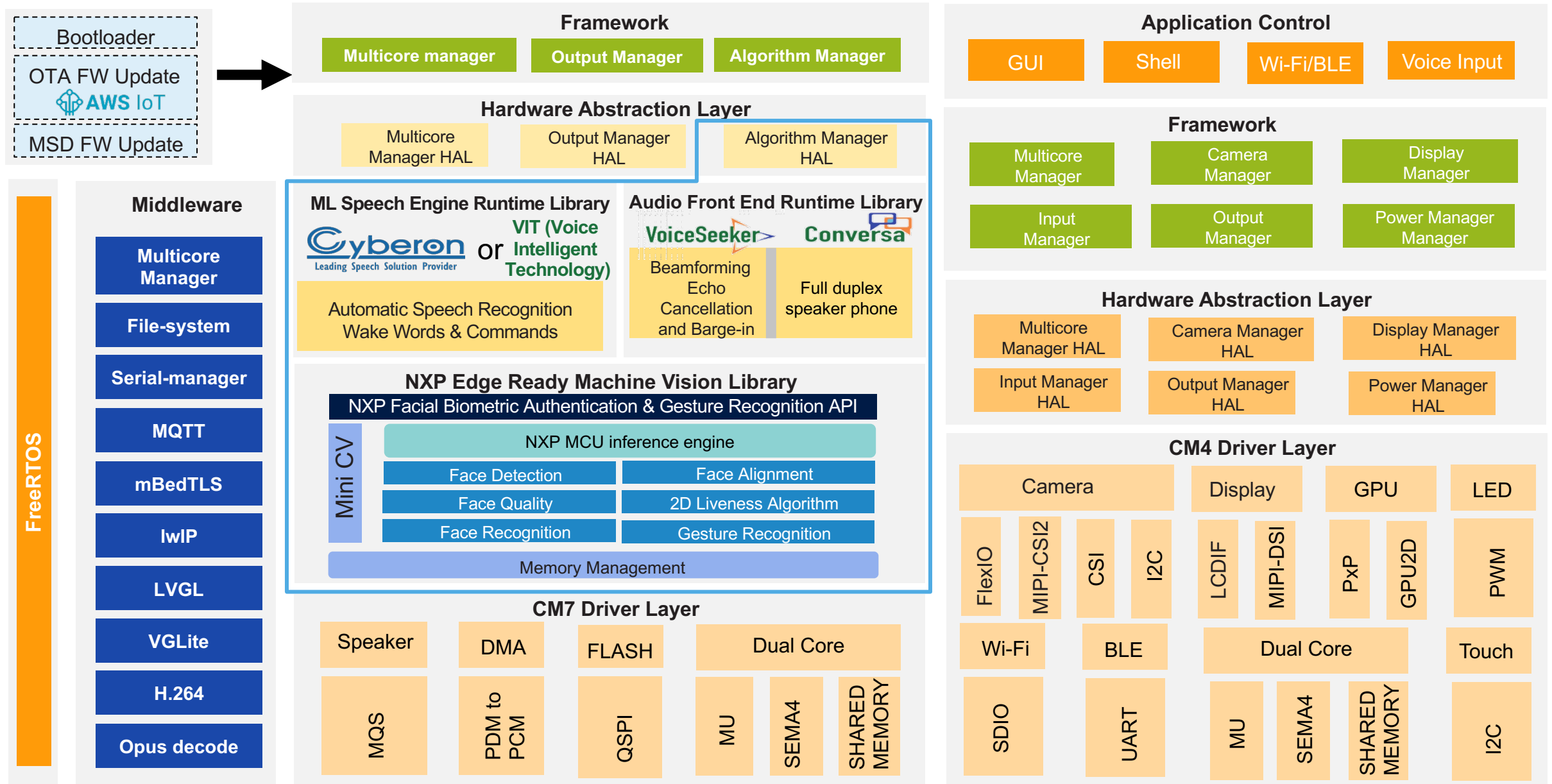
Far-Field Voice Control

- 2 onboard digital microphones. Additional microphones available via expansion board (not included)
- VoiceSeeker integration to support acoustic echo cancellation, noise reduction, beamforming and barge-in
- VIT integration to support wake word and local voice command recognition capabilities
- 3rd-party offline voice control available as complementary option
- Multi-language wake word and automatic system language configuration based on detected language

Wireless Connectivity

- Dual-band 1x1 Wi-Fi 4 + BLE combo 5.2: IW416
- Cloud-based device management, user data management, OTA, etc.
- Matter protocol support

SMART HMI SOLUTION SOFTWARE BLOCK DIAGRAM



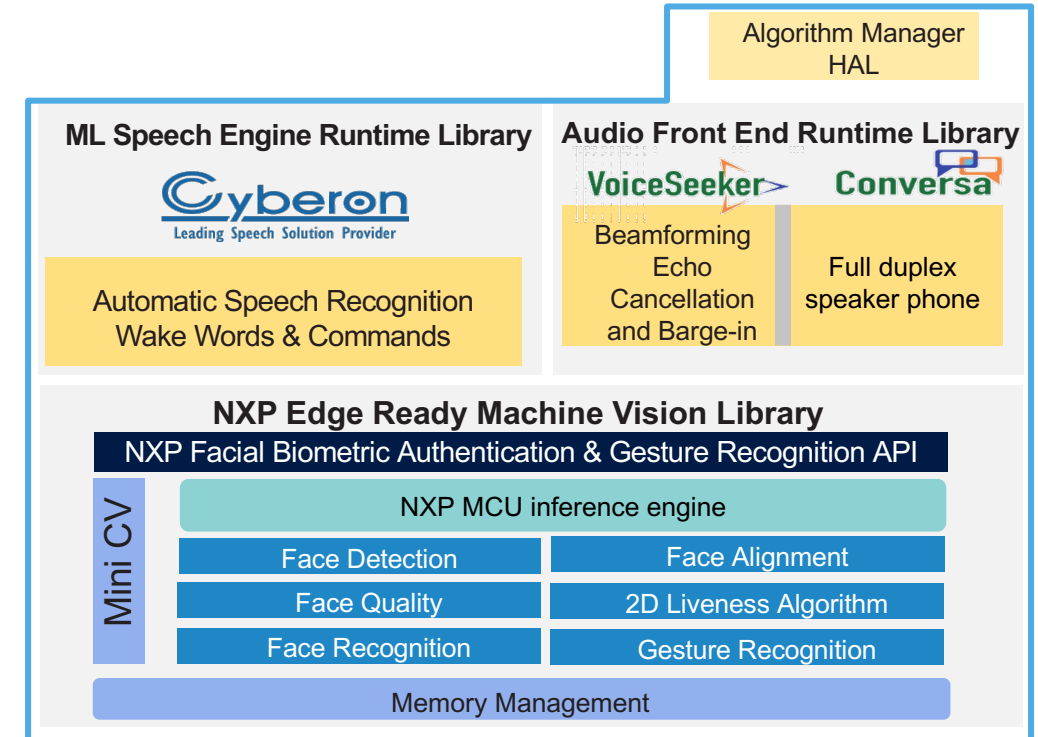
KEY ALGORITHM COMPONENTS

- **Local voice algorithm pipeline**

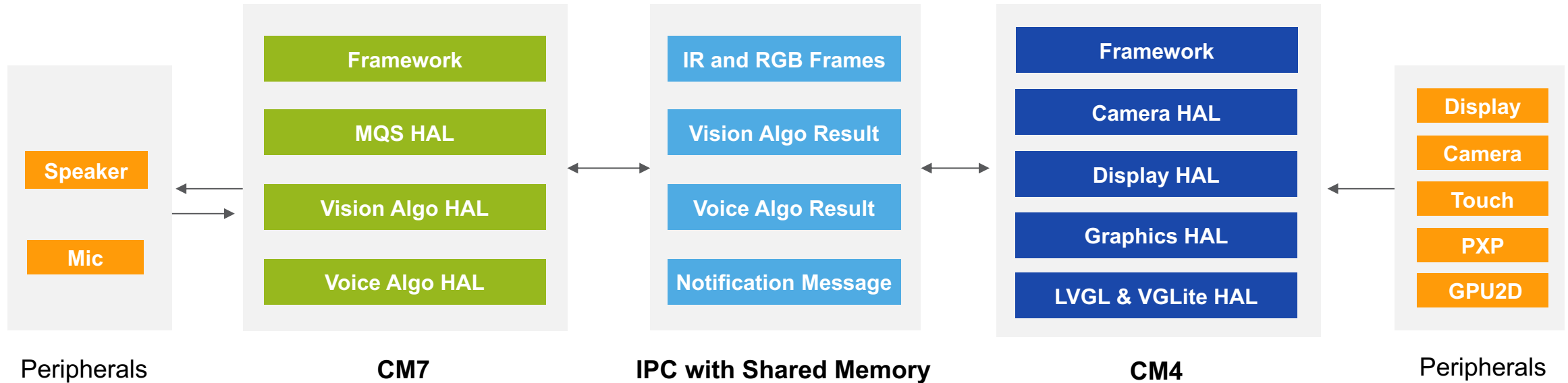
- AFE(Audio Front End)
 - VoiceSeaker(NXP)
 - Conversa(NXP)
- ASR(Automatic Speeck Recognition)
 - VIT(NXP)
 - Cyberon(ThirdParty)

- **Vision algorithm pipeline**

- Optimized MCU inference engine(NXP)
- AI model and Non-AI algorithm (NXP)
 - Face detection/alignment/quality/liveness
 - Face recognition
 - Gesture recognition



SMART HMI SOLUTION SOFTWARE ARCHITECTURE



CM7 (Vision and Voice algorithm accelerator):

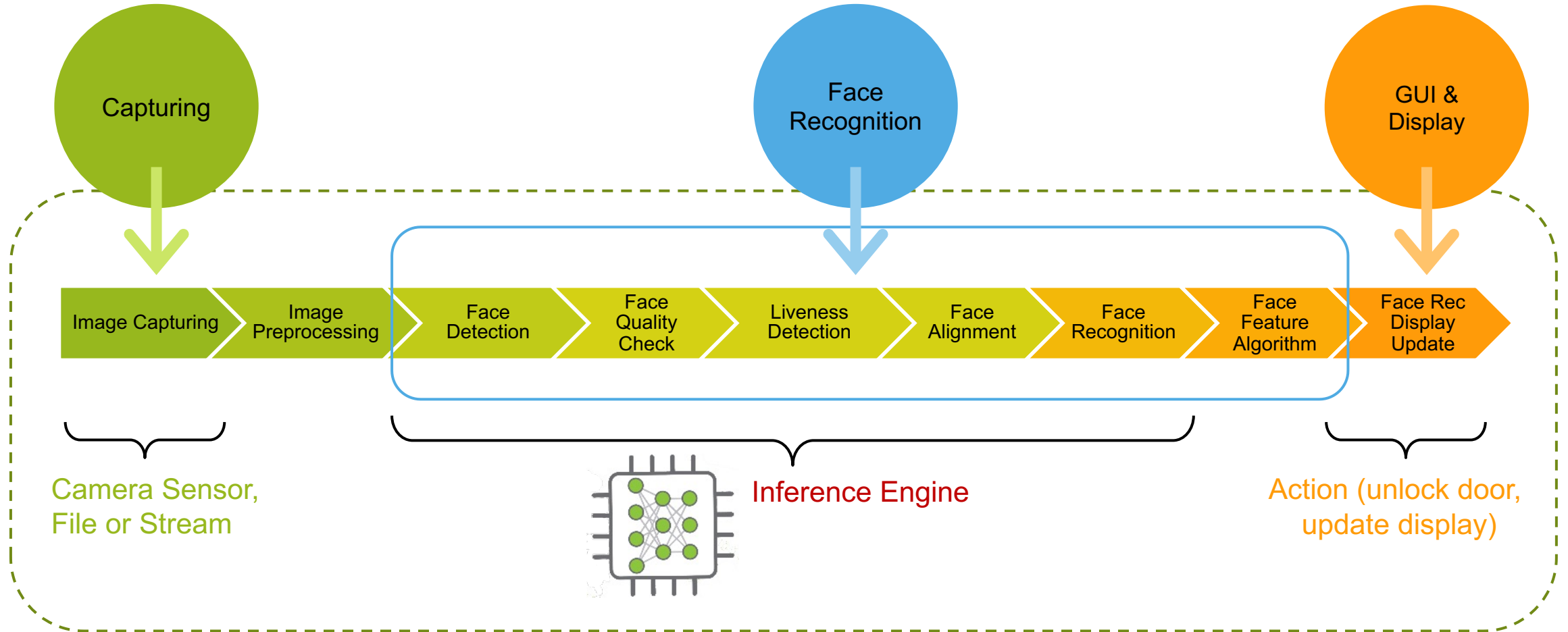
- Framework
- Vision algorithm with VGA input frames
- Voice algorithm (AFE + ASR) with mic input
- MQS audio playback
- IPC communication with shared memory



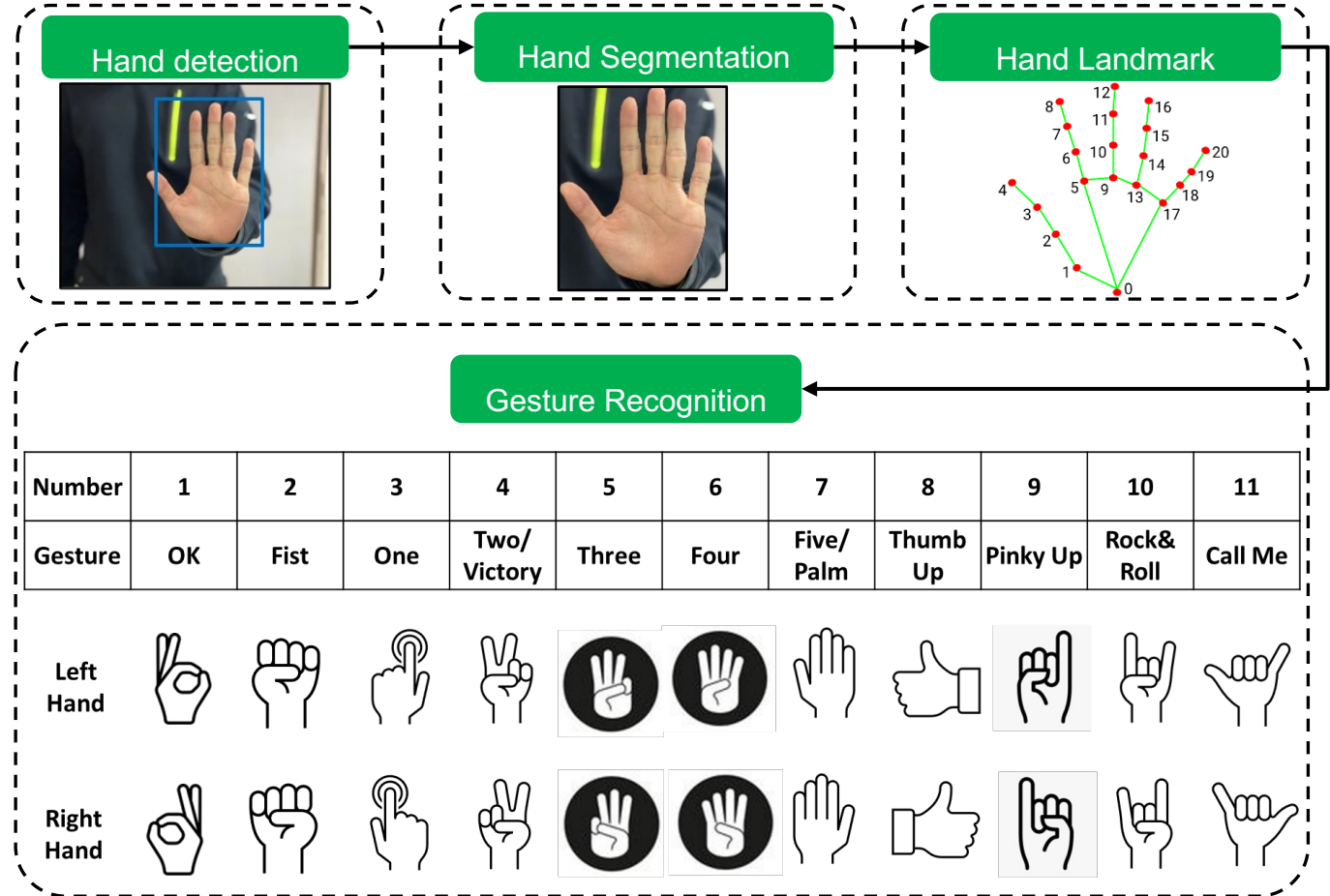
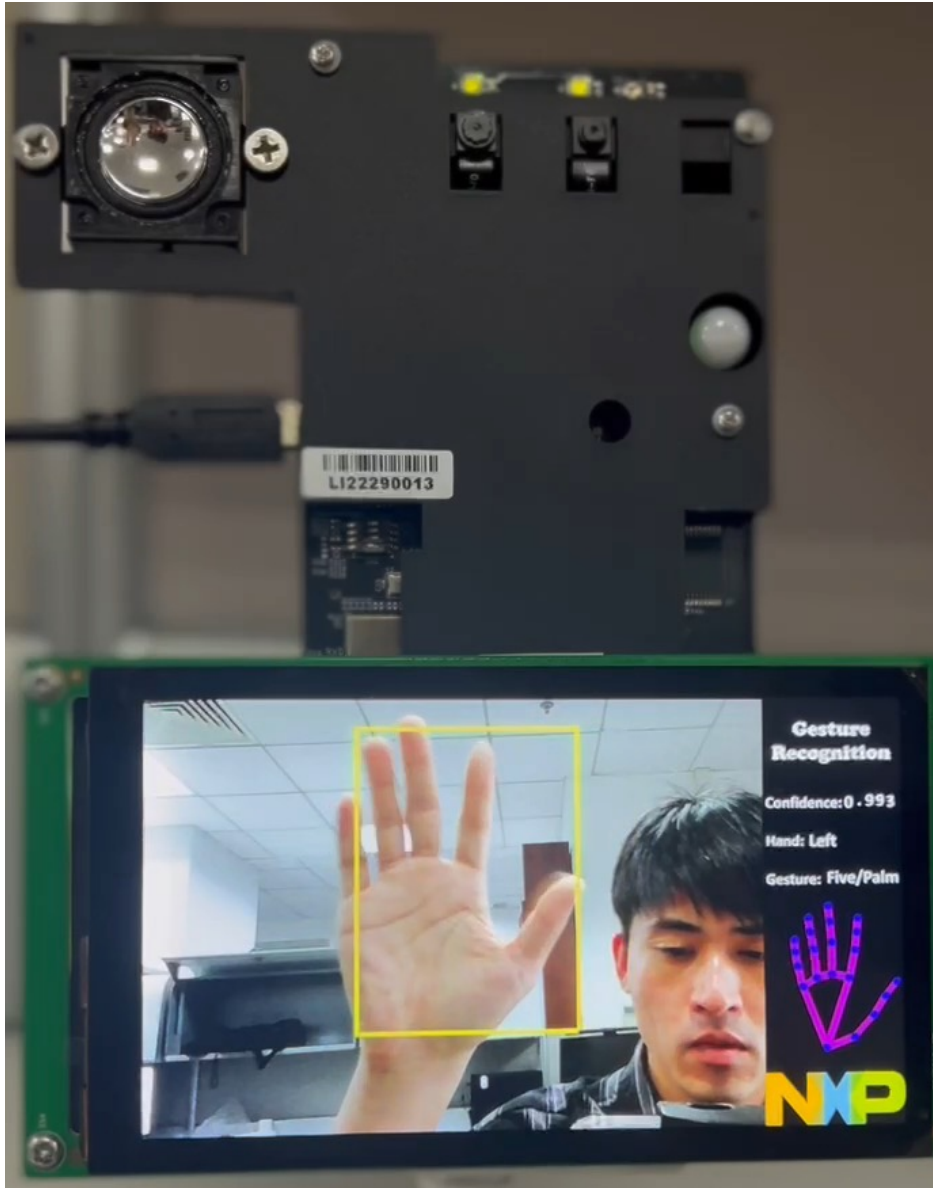
CM4 (UI and System control unit):

- Framework
- CSI/MIPI Camera preview @VGA
- LVGL GUI @720p with VGLite 2D GPU acceleration
- Vision algorithm input frames color space conversion with PxP
- Touch panel input
- IPC communication with shared memory

FACIAL BIOMETRIC AUTHENTICATION SOFTWARE PIPELINE



GESTURE CONTROL VIA HAND SHAPE RECOGNITION ON i.MX RT117H



Light-weighted MCU optimized pipeline and model provides low latency and reduced footprint.

SUMMARY

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LEARN MORE

NXP – Resources

- [AI and Machine Learning at NXP Semiconductors \(www.nxp.com/ai\)](http://www.nxp.com/ai)
- [eIQ® ML Software Development Environment \(www.nxp.com/eiq\)](http://www.nxp.com/eiq)
- [eIQ ML/AI Training Series \(www.nxp.com/mltraining\)](http://www.nxp.com/mltraining)
- [eIQ Neutron Neural Processing Unit \(NPU\) | NXP Semiconductors \(www.nxp.com/neutron\)](http://www.nxp.com/neutron)
- [eIQ® ML Watermarking Model Protection Tool Demo | NXP Semiconductors](http://www.nxp.com/mcu-smhmi)
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