



Webinar

Bringing intelligence to building automation with AM6xA Arm-based processors

Mahir Kaheri

Product marketing engineer

Dr. Qutaiba Saleh

System application engineer for artificial intelligence

Eyal Cohen

Systems engineer, Building Automation

NICOLE DRE...



TIFFANY SMI...



AREA OF INTEREST 1

JOSEPH MAR...



09 SHANGHAI



12 CHICAGO



12 CHICAGO



12 CHICAGO



12 CHICAGO



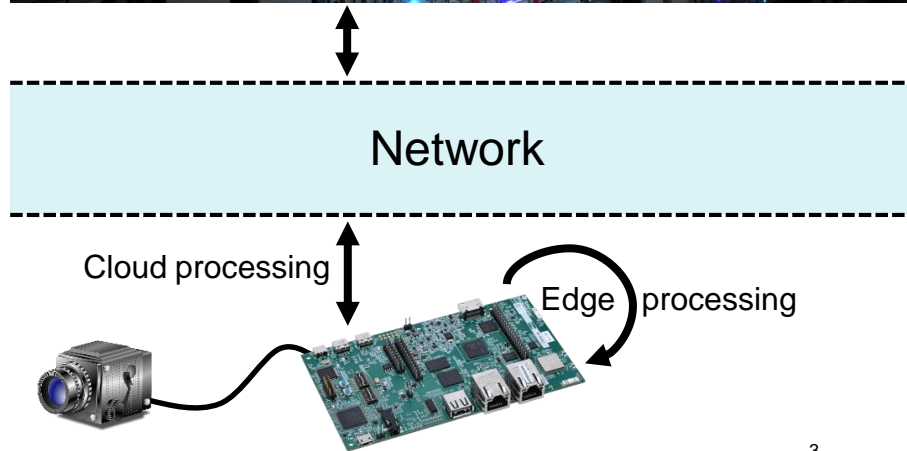
Agenda

- Arm-based processors product overview
- Arm-based processors in building automation
- Edge AI HW & SW
- Demos
 - People tracking
 - Multi camera
 - AI Box
 - Video Stream over Wi-Fi®
- System overview
 - Security gateway
 - Video doorbell
 - Thermostat

The edge vs. the cloud

Edge AI: artificial intelligence in an edge computing environment, where computing is done close to where data is collected.

Edge AI Local processing	Cloud AI Cloud processing
Local processing	Cloud processing
Lower latency	Higher latency
Higher privacy	Lower privacy
No costs for network/cloud compute	Costs for network/cloud compute
Lower performance	Higher performance

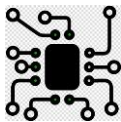


Scalable performance for building automation

Arm-based processors for building automation



Energy efficient compute



Low-power and security



Edge AI capable for smart-vision analytics

Scalable performance | Efficient compute

Our cost-optimized Arm-based processors let you design low-power, energy-efficient communication, smart HMI, HVAC, and machine vision applications in less time.

AM623/AM625

Cortex-A53 based
general-purpose
processor



AM62A

Cortex-A53 based
AI vision processor



AM64x

Cortex-A53 based
networking processor



Unified open-source software platform and tools

SIL-2/SIL-3 compliance - comprehensive safety collateral on [ti.com](https://www.ti.com)

Building automation use cases

Communication & HMI



Gateways, Smart locks

AM335 & AM623



Smart HMI (Thermostats)

HVAC controller



Fire control panel and safety systems

AM623/5 & AM62-Plus



HVAC controller

Machine vision & analytics



Vision works (surveillance), building security system & people/object monitoring/detection

AM62A



1x Cortex A8
Video: 1x Display
GPU: 1.6 GFLOPS
Package: 13x13/15x15mm; <6-1W

Released on TI.com



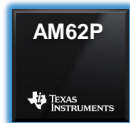
1-4x A53; 1x M4F
Video: 2x Display; SW Codec
Package: 13x13mm; <1.5W

Released on TI.com



1-4x A53; 1x M4F
Video: 2x Display; SW Codec
GPU: 8 GFLOPS
Package: 13x13mm; <1.5W

Released on TI.com



1-4x A53; 1x R5F
Video: 4K30 Codec; 3x HD display
GPU: 50 GFLOPS
Package: 17x17mm; <3Q

Now sampling



1-4x A53; 1xR5F;
Camera: CSI1; 5MP ISP; AI: 2 TOPS
Video: 1x Display 2K codec
Package: 18x18mm <5W

Released on TI.com

- Scalability of processing from low end gateways to system controllers and machine vision applications
- TI has scalable roadmaps from single-core ARM to octal-core ARM: General purpose, video processing and edge AI

Now Sampling



Released



Edge AI HW and SW

Edge AI Demos

Dr. Qutaiba Saleh

System Applications Engineer for AI – Processors

AM6x edge AI vision processor family

AM62



AM62A



AM67A



AM68A



AM69A



ML Performance	Arm based ML	2 TOPS	4 TOPS	8 TOPS	32 TOPS
CPU	4x A53	4x A53	4x A53	2x A72	8x A72
ISP	NA	315 MP/s	600 MP/s	480 MP/s	480 MP/s
Video codec	NA	240 MP/s (4K@30FPS)	240 MP/s (4K@30FPS)	480 MP/s (4K@60FPS)	480 MP/s (4K@60FPS)
GPU	3D 8GFLOPS	NA	3D 50GFLOPS	3D 50GFLOPS	3D 50GFLOPS
4K frame rate	30 fps	30 fps	60 fps	60 fps	60 fps (two simultaneous streams)

Scaling with Hardware + Software



SDK & Academy

General purpose software

Main Line OS **Linux**



No-RTOS, FreeRTOS



Open-source **Android** available

Academy & tools

Foundational Linux **training** –
featuring customer board porting

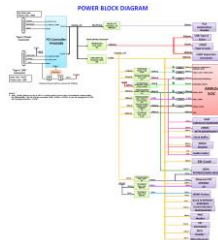


Graphical tools to help config
the device (DDR, Pinmux)



Hardware

EVMs and schematics



SoMs

Community-led boards
and SW ecosystem
focused on small
companies



Tools & references
in the **TI Developer Zone**



Edge AI SDK
Edge AI Studio



ISP tuning



011100
100010
001111

Out-of-the-box
applications ex.



1000+ customers evaluating/developing on TI MPUs across 150+ EEs

Deep learning programming | flexible, easy & HW agnostic

Program with industry standard APIs

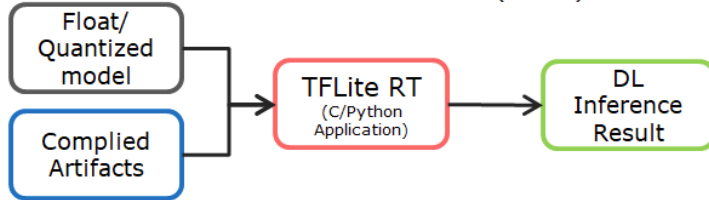


TFLite runtime based user work flow



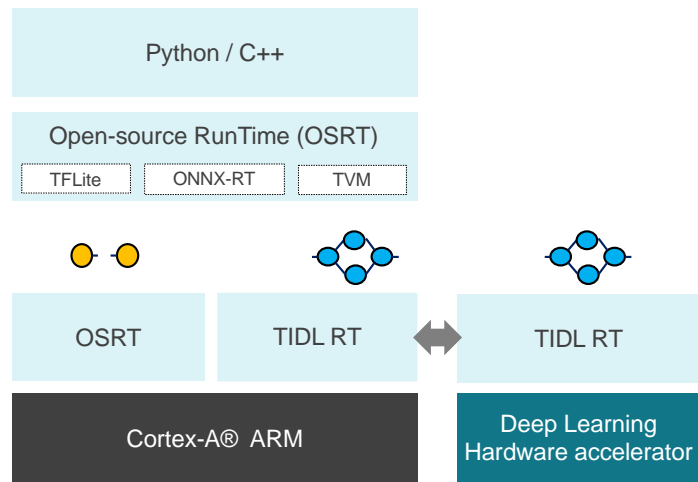
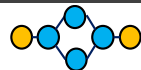
Model Compilation on x86 - Linux (PC)

Model Inference on ARM - Linux (TI SoC)



TFLite runtime based user work flow

Accelerate with production ready software

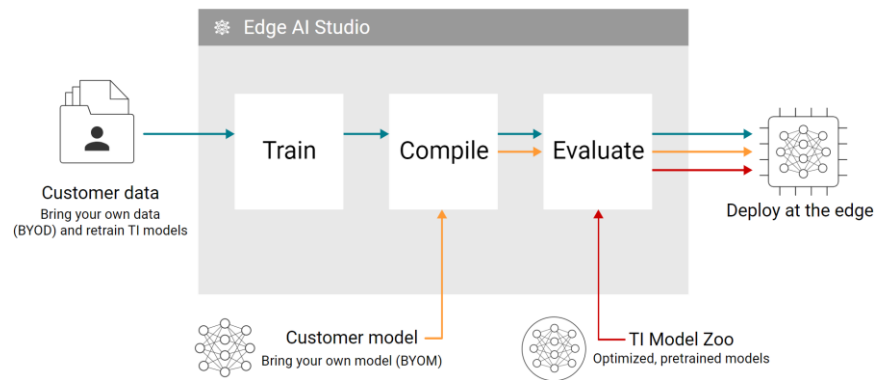


*TVM operators auto compiles for C7x - if not part of hand-optimized TIDL library

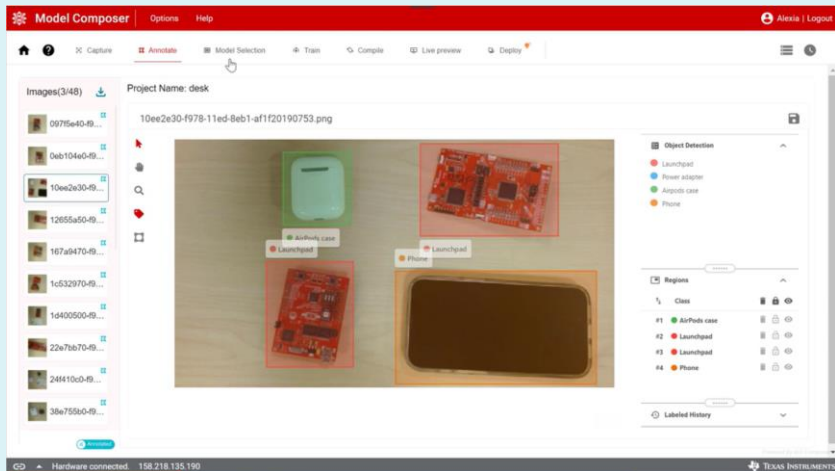
Edge AI Studio

Edge AI Studio is a collection of tools that enable development, benchmarking and deployment of AI applications.

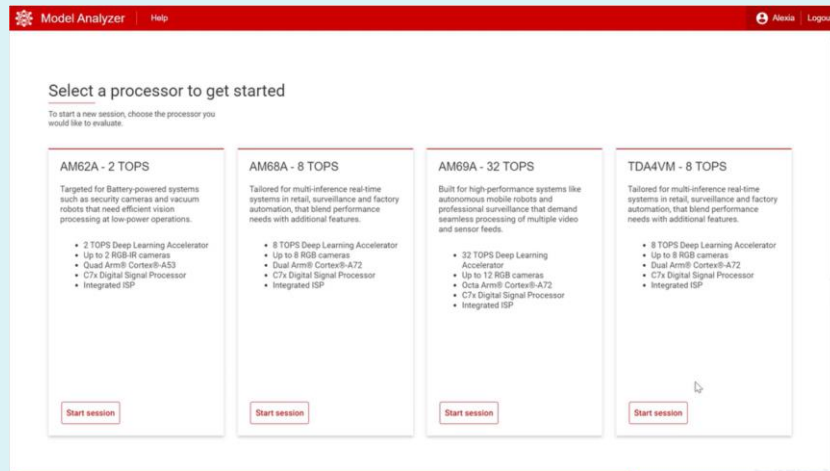
<https://dev.ti.com/edgeaistudio/>



Model Composer



Model Analyzer



Building automation demos

Edge AI building automation examples

People tracking



- Retail
- Building Security
- Fire Safety

Multiple camera AI AI Box



- Building Security
- AI Box
- HVAC

Edge AI and video stream over Wi-Fi



- AI Box
- Doorbell
- Infotainment & Cluster

More examples at: <https://www.ti.com/edgeaiprojects>

People tracking on AM62A Arm-based processor

Highlighted applications

Retail:

- Most visited shelves in a store
- Customer counter
- Wait time at service line
- Customer behavior analysis

Building automation/civil:

- Smart HVAC Systems & Thermostat
- Road/hallway usage
- Wait time at traffic crossing

Security & Safety:

- Malicious activities detector
- Health emergency detector

Other applications:

- Crowd management/analysis
- Livestock monitoring



Dashboard features

Heatmap: most occupied
Total visitors counter
Current Occupancy
Histogram of total time
Histogram of still time

Live feed features

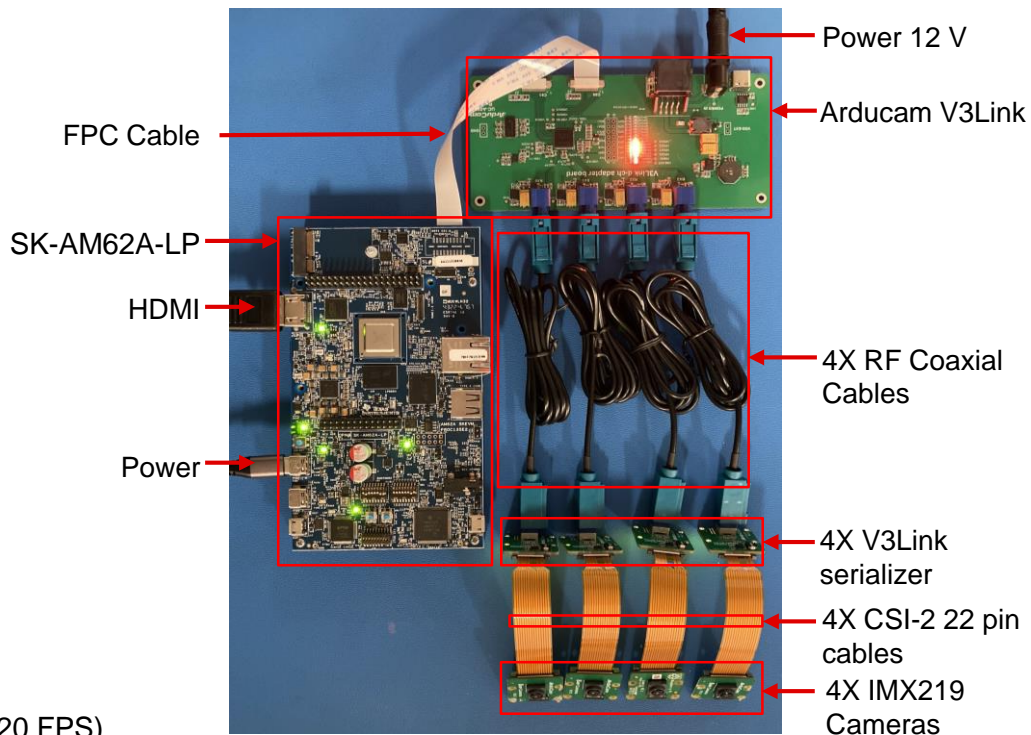
People Tracking
Total duration on frame
Still duration on frame

[TexasInstruments-Sandbox / edgeai-gst-apps-people-tracking](#) Public

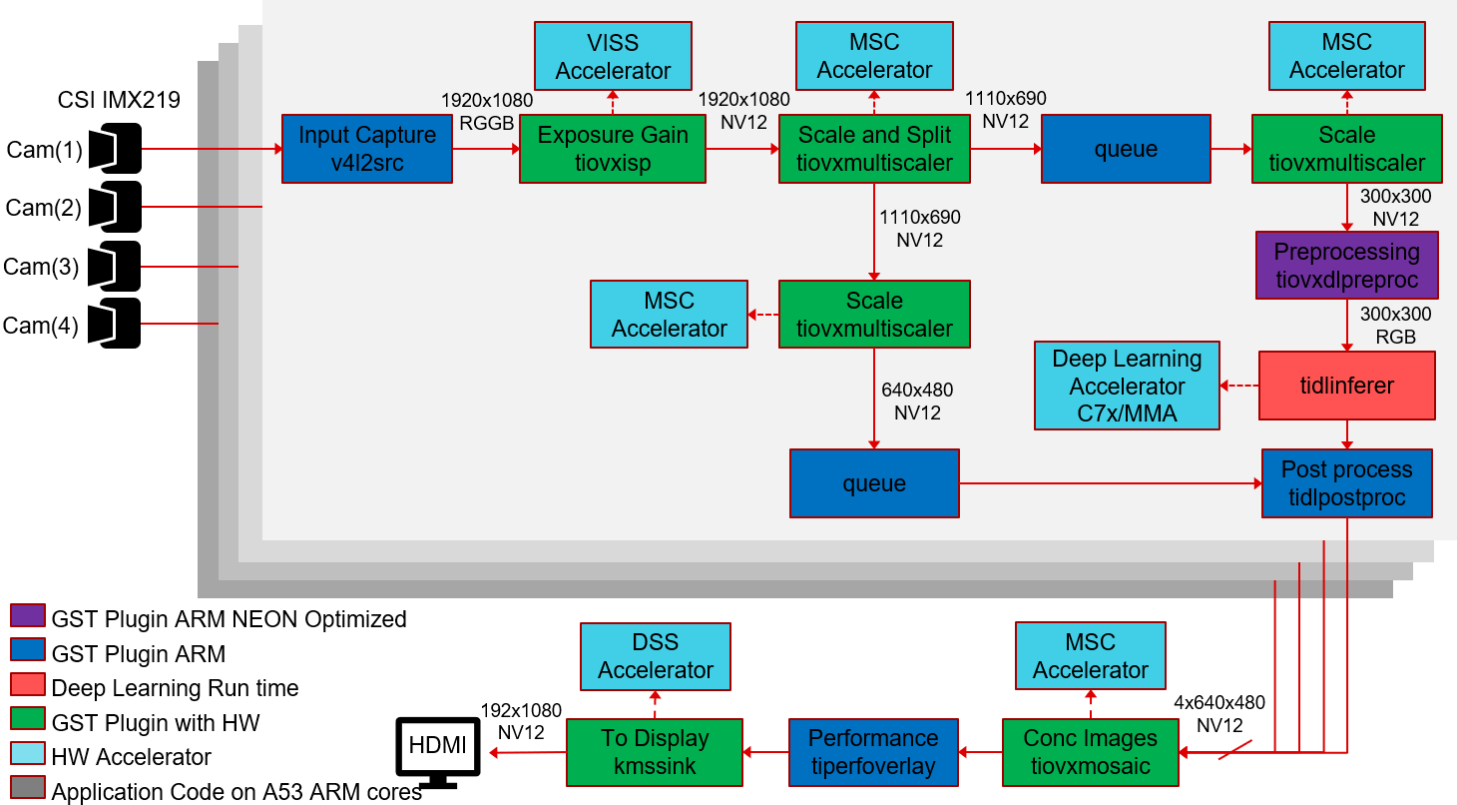
Multiple cameras with AI



- Four cameras 1080@30FPS each equivalent 4K@30FPS
- V3Link to connect four cameras through 1 MIPI CSI-2
- AM62A ISP performs pre-processing of raw videos
- Machine Learning Inference (mobile net v1 on four cameras: 120 FPS)



gStreamer pipeline

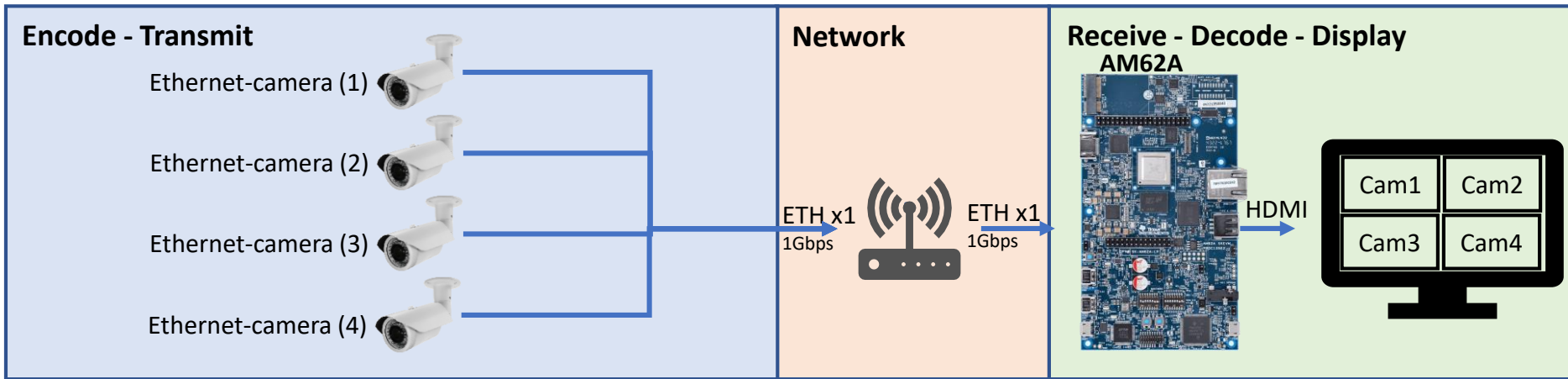


Performance

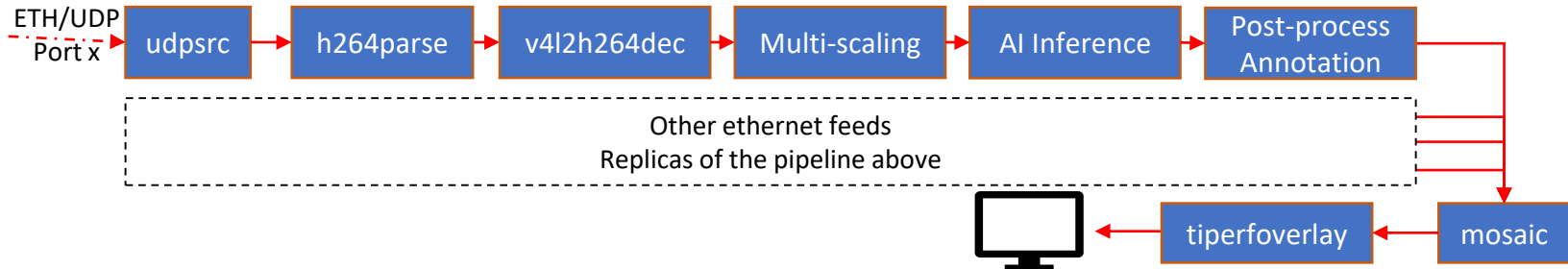
Appl	Pipeline (operation)	Output	FPS avg pipelines	FPS total	MPUs A53s @ 1.25 GHz [%]	MCU R5 [%]	DLA @ 850 MHz [%]	VISS [%]	MSC0 [%]	MSC1 [%]	DDR Rd [MB/s]	DDR Wr [MB/s]	DDR Total [MB/s]
No	Baseline No operation	NA	NA	NA	1.87	1	0	0	0	0	560	19	579
Camera only	Stream to Screen	Screen	30	120	12	12	0	70	61	60	1015	757	1782
	Stream over ethernet	UDP: 4 ports 1920x1080	30	120	23	6	0	70	0	0	2071	1390	3461
	Record to files	4 files 1920x1080	30	120	25	3	0	70	0	0	2100	1403	3503
Cam with deep learning	Deep learning: Object detection MobV1-coco	Screen	30	120	38	25	86	71	85	82	2926	1676	4602
	Deep learning: Object detection MobV1-coco and Stream over ethernet	UDP: 4 ports 1920x1080	28	112	84	20	99	66	65	72	4157	2563	6720
	Deep learning: Object detection MobV1-coco and record to files	4 files 1920x1080	28	112	87	22	98	75	82	61	2024	2458	6482

16

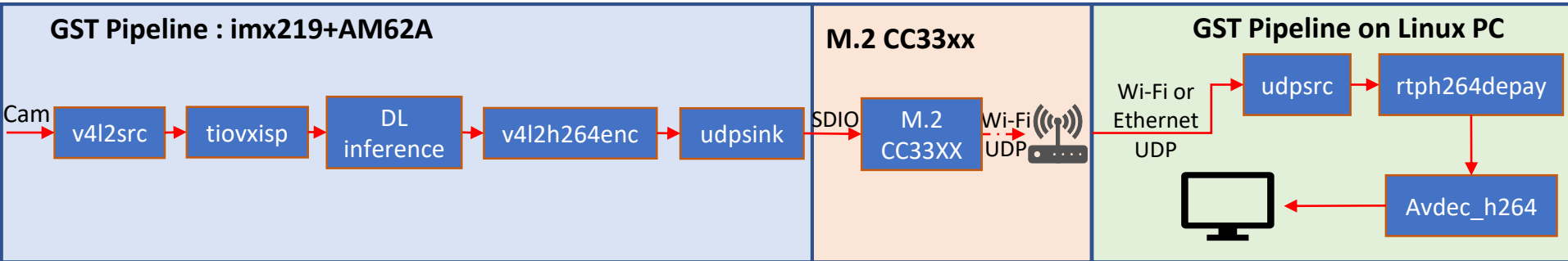
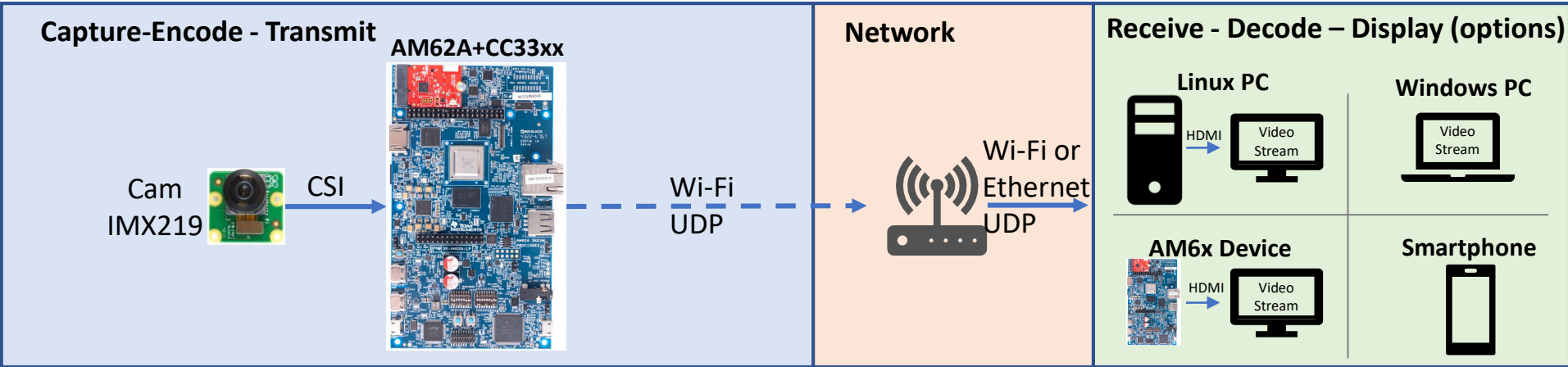
AI box with IP cameras



GST pipeline on AM62A (receiver)



Video Stream over Wi-Fi using CC33xx



Implementation (hardware)

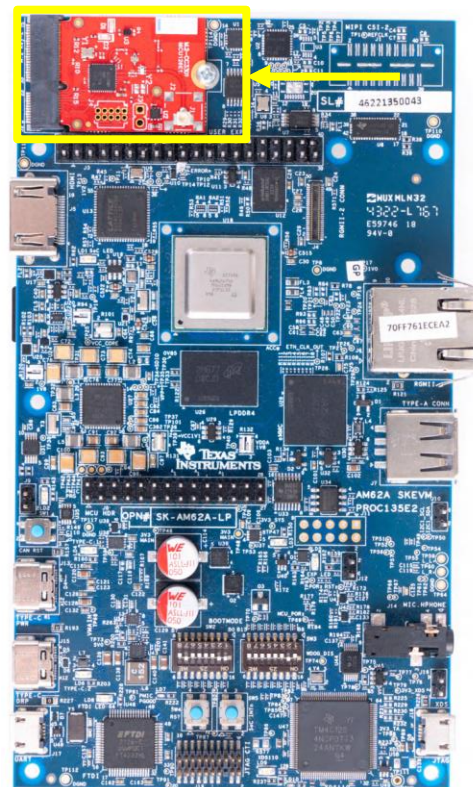
M.2 CC33xx wireless MCU

- Wi-Fi 6 (802.11ax) with 802.11a/b/g/n/ac backward compatibility
- Bluetooth® Low Energy 5.4 in CC33x1 devices
- 2.4GHz (CC330x) and 5GHz (CC335x) PA with up to +20.5dBm output power
- Up to 65Mbps UDP throughput
- Onboard antenna with option for U.FL/SMA based testing
- Seamless integration with MPU platforms
 - SK-AM62B-P1, SK-AM62A-LP, SK-AM62-LP

AM62A Arm-based processor

- 1-4x Cortex-A53 & 2x R5F
- 32-bit DDR @ 3733 MT/s
- Up to 2 TOPS Deep Learning accelerator
- 315MPix/s ISP & MIPI-CSI2-RX-4L camera interface
- H.264/H.265 encode/decode
- 2 Watts typical

CC33xx board



Implementation: gStreamer pipeline

Video capture and transmit (AM62A SoC)

```
gst-launch-1.0 -v \  
v4l2src device=/dev/video-imx219-cam0 io-mode=5 ! queue leaky=2 ! video/x-bayer, width=1920, height=1080, format=rggb ! \  
tiovxisp sensor-name=SENSOR_SONY_IMX219_RPI dcc-isp-file=/opt/imaging/imx219/linear/dcc_viss.bin format-msb=7 \  
sink_0::dcc-2a-file=/opt/imaging/imx219/linear/dcc_2a.bin sink_0::device=/dev/v4l-subdev2 ! \  
video/x-raw, format=NV12 ! queue ! tiperfoverlay title="IMx219 to udp stream" overlay-type=graph ! \  
v4l2h264enc ! h264parse ! rtpH264pay ! udpsink host=<receiver ip> port=5000 sync=false \  

```

Video capture, ML inference and transmit (AM62A SoC)

```
gst-launch-1.0 -v \  
v4l2src device=/dev/ /video-imx219-cam0 io-mode=5 ! queue leaky=2 ! video/x-bayer, width=1920, height=1080, format=rggb ! tiovxisp sensor-name=SENSOR_SONY_IMX219_RPI dcc-isp-file=/opt/imaging/imx219/linear/dcc_viss.bin format-msb=7 sink_0::dcc-2a-file=/opt/imaging/imx219/linear/dcc_2a.bin sink_0::device=/dev/v4l-subdev2 ! video/x-raw, format=NV12 ! \  
tiovxmultiscaler name=split_01 src_0::roi-startx=0 src_0::roi-starty=0 src_0::roi-width=1920 src_0::roi-height=1080 target=0 \  
split_01. ! queue ! video/x-raw, width=480, height=416 ! tiovxmultiscaler target=1 ! video/x-raw, width=416, height=416 ! tiovxdlpreproc model=/opt/model_zoo/ONR-OD-8200-yolox-nano-lite-mmdet-coco-416x416 out-pool-size=4 ! application/x-tensor-tiovx ! tidlinferer target=1 model=/opt/model_zoo/ONR-OD-8200-yolox-nano-lite-mmdet-coco-416x416 ! post_0.tensor \  
split_01. ! queue ! video/x-raw, width=1280, height=720 ! post_0.sink \  
tidlpostproc name=post_0 model=/opt/model_zoo/ONR-OD-8200-yolox-nano-lite-mmdet-coco-416x416 alpha=0.200000 viz-threshold=0.600000 top-N=5 display-model=true ! \  
queue ! tiperfoverlay title="Object Detection" ! v4l2h264enc ! h264parse ! rtpH264pay ! udpsink host=<receiver ip>port=5000 sync=false \  

```

Receiver: Linux PC

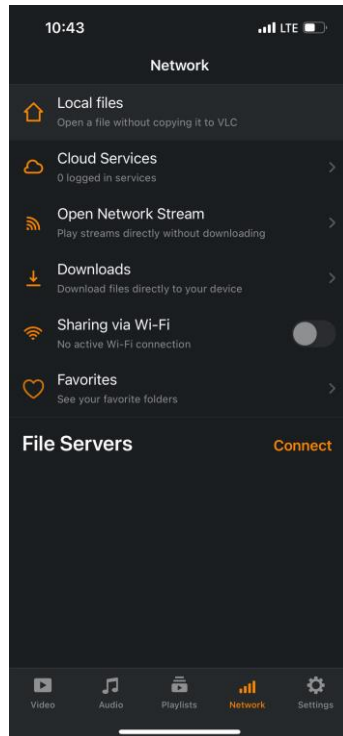
```
gst-launch-1.0 -v \  
udpsrc port=5000 ! 'application/x-rtp, encoding-name=H264, payload=96' ! rtpH264depay ! avdec_h264 ! videoconvert ! autovideosink
```

Implementation: Receive on smartphone and Windows using VLC media player

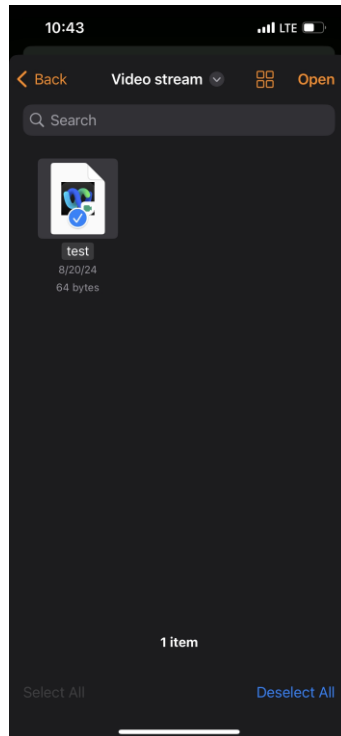
Create test.sdp simple text

```
c=IN IP4 0.0.0.0
m=video 5000 RTP/AVP 96
a=rtpmap:96 H264/90000
```

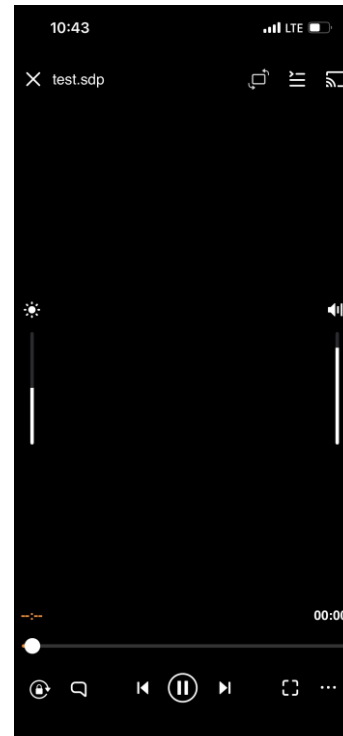
VLC: Network tab local files



Navigate to /open test.sdp



Waiting for stream



Stream received



Results

- The videos are successfully captured, encoded (H.264), and streamed over Wi-Fi using CC33xx wireless MCU.
- The stream can be received/displayed using Linux PC, Windows PC, smartphone, and another AM6x device.
- The videos shows streams from AM62A processor to a smartphone.
- Camera: imx219 with 1920x1080 @ 30 FPS.
- Table below shows AM62A resource utilization.

ML Model	Rate each [FPS]	CPU (4x A53 @ 1.2 GHz) [%]	DLA @ 850 MHz [%]	VISS [%]	MSC0 [%]	MSC1 [%]	DDR Rd [MB/s]	DDR Wr [MB/s]	DDR Total [MB/s]
NA	30	7.86	0	17.3	0	0	860	309	1169
Yolox-nano-lite	30	10.61	28	20.38	28.27	3.3	1972	400	1772

AM62xA Block Diagrams

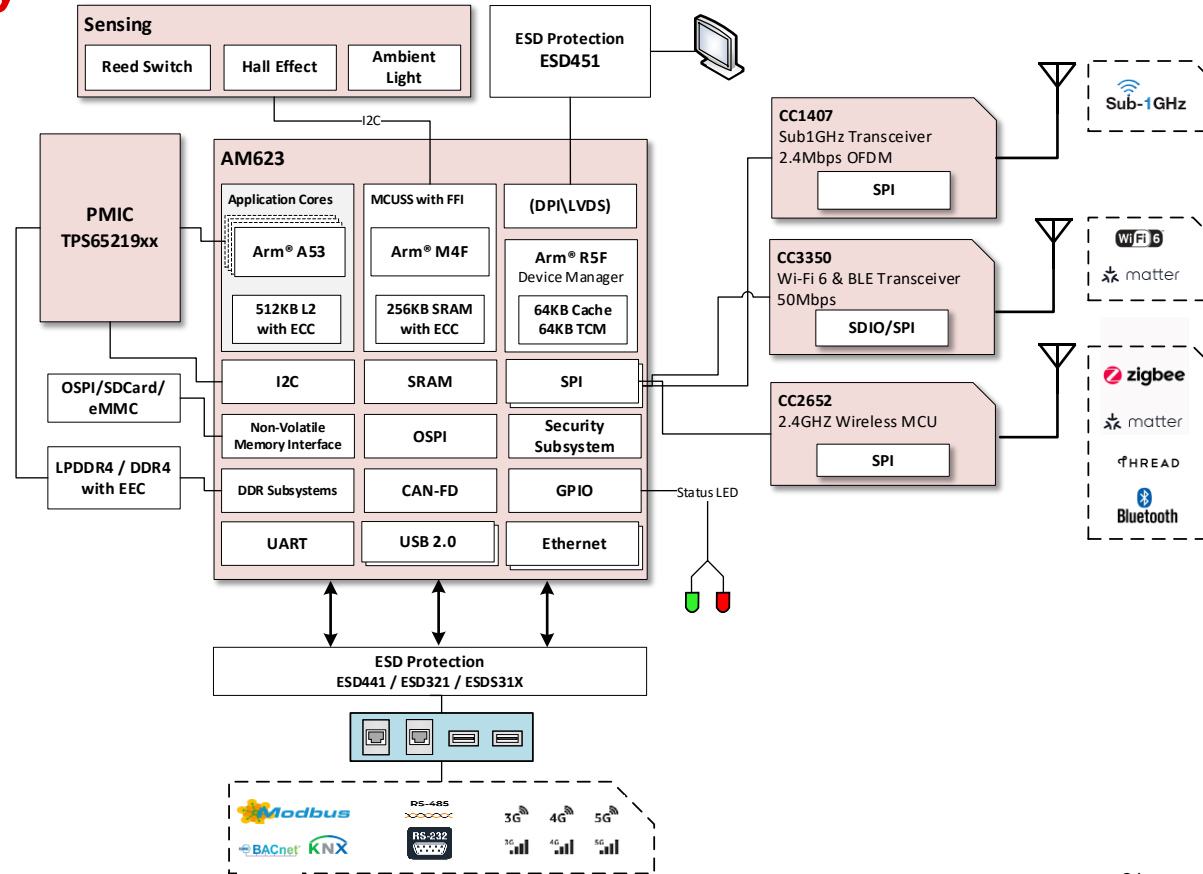
IoT Gateway, Video Door Bell and Thermostat

Eyal Cohen

System Engineer – Building Automation Systems Team

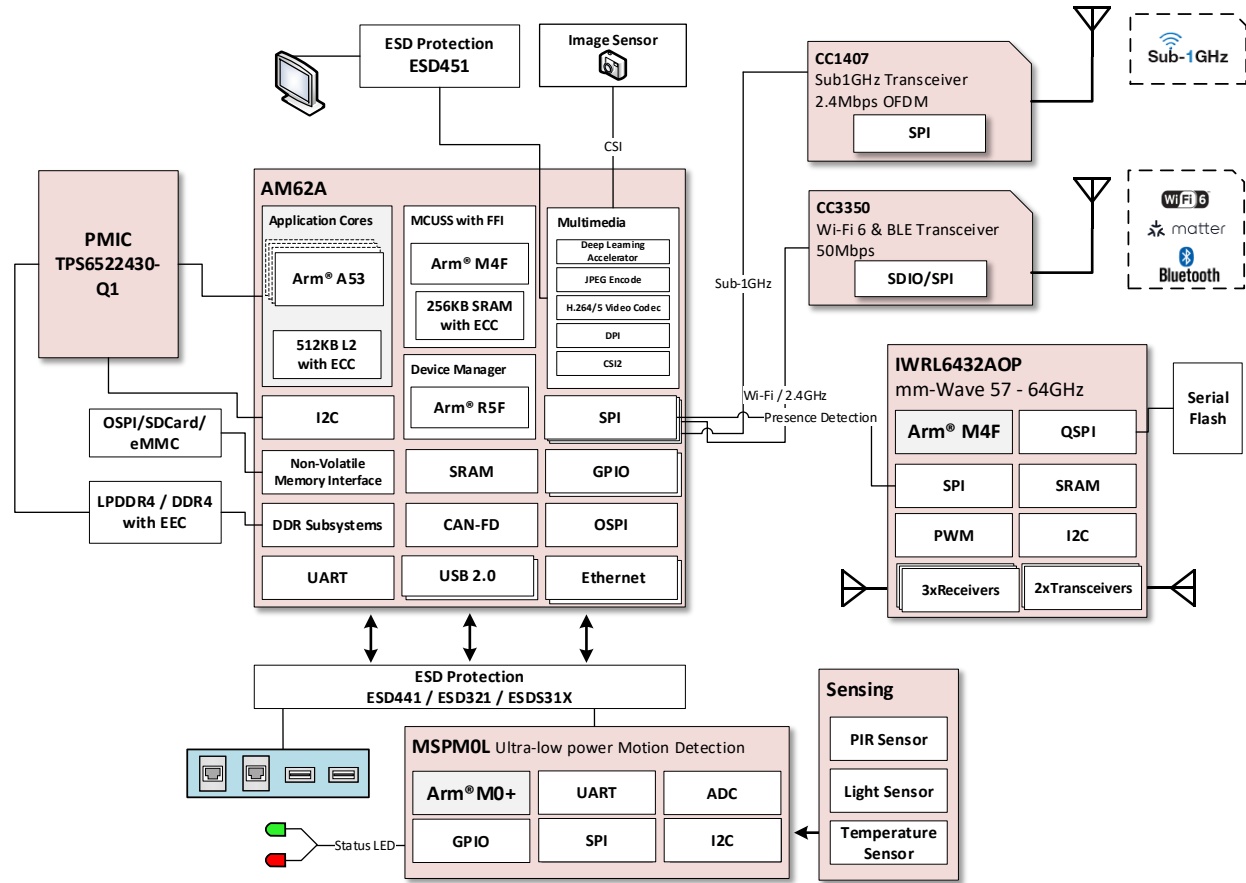
Building Security Gateway

- **AM623** Arm-based processor with a display driver
- **CC3350** wireless MCU – Wireless Wi-Fi and BLE Transceiver
- **CC2652** wireless MCU – Supporting multi 2.4GHZ protocols (Open-Thread, Zigbee, BLE5, Matter)
- **CC1407** – Newest Sub1GHz OFDM Transceiver supporting up to 2.4Mbps



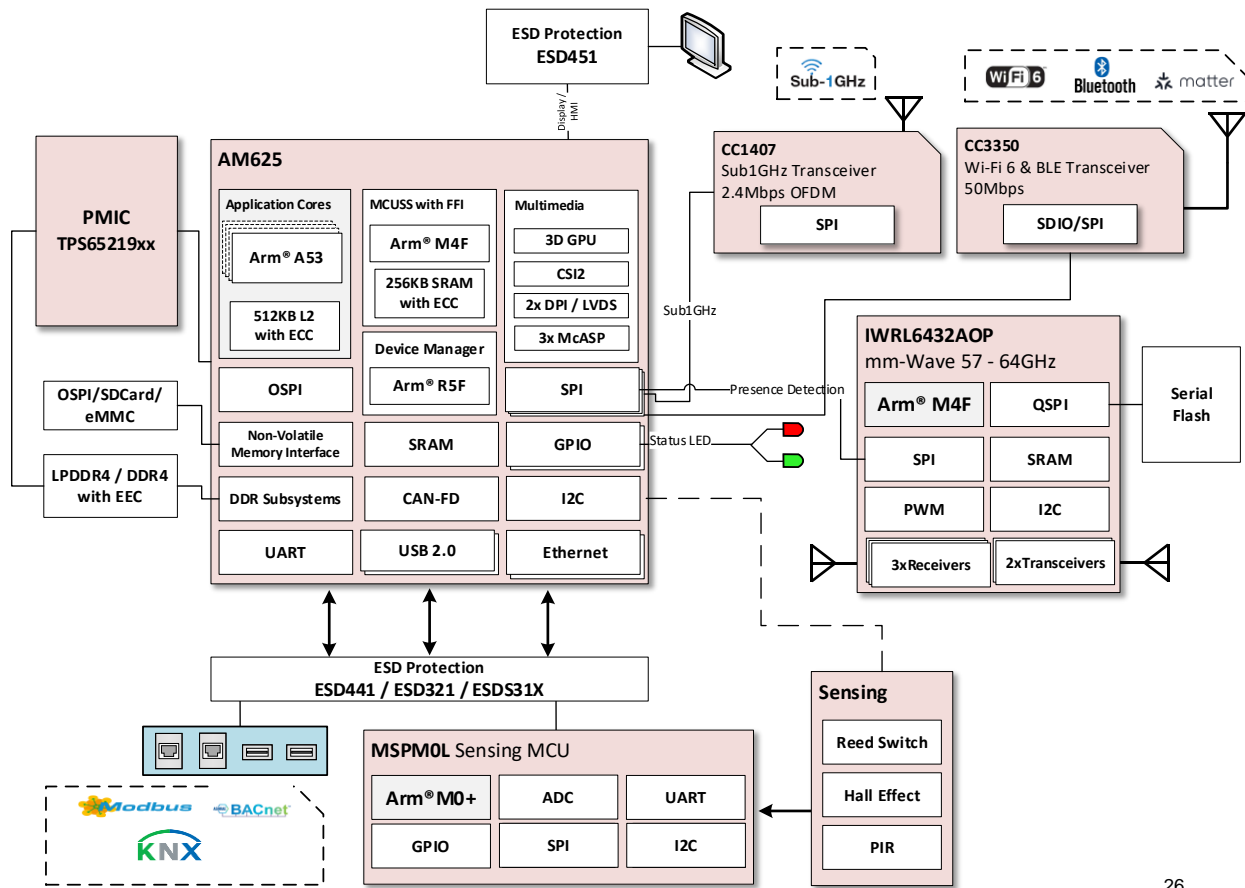
Video Door Bell

- **AM62A** Arm-based processor with Deep Learning Accelerator, JPEG Encode and H.264/5 Video codec
- **CC33XX** wireless MCU – Wireless Wi-Fi and BLE Transceiver
- **CC1407** – Sub1GHZ OFDM up to 2.4Mbps Transceiver supporting long-range video door bell applications
- **IWRL6432AOP** – Low power antenna-on-package mmWave radar sensor for presence detection
- **MSPM0L** MCU – Full motion detection by TI solution offering SW and HW for PIR detector up to 12m.



Thermostat


- **AM625** Arm-based processor with a **3D GPU**
- **CC33XX** wireless MCU – Wireless Wi-Fi and BLE Transceiver
- **CC1407** – Sub1GHZ OFDM Transceiver up to 2.4Mbps
- **IWRL6432AOP** – Low power antenna-on-package mmWave radar sensor for presence detection
- **MSPM0L** MCU – Full motion detection by TI solution offering SW and HW for PIR detector up to 12m.



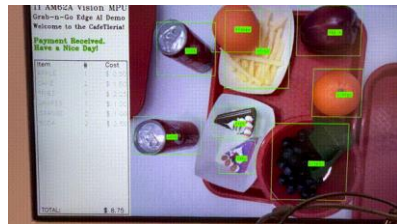
Edge AI examples


Defect detection



 TexasInstruments /
edgeai-gst-apps-defect-detection


Smart retail scanner



 TexasInstruments /
edgeai-gst-apps-retail-checkout


Barcode detection



 TexasInstruments /
edgeai-gst-apps-barcode-reader

License plate recognition



 TexasInstruments /
edgeai-gst-apps-lpr

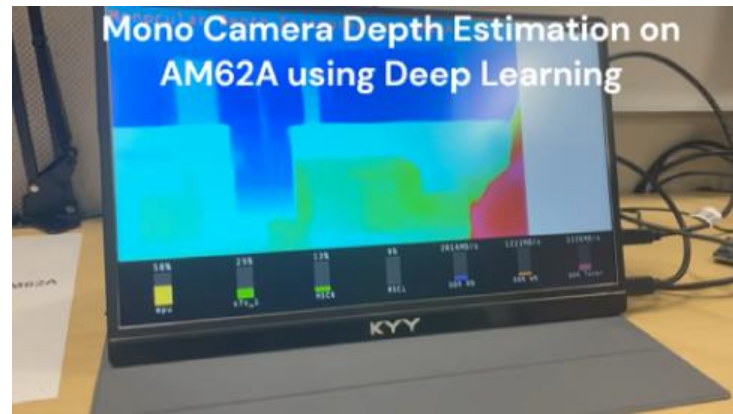
More examples at: <https://www.ti.com/edgeaiprojects>

New & Upcoming Examples

People Tracking



Depth estimation



More examples at: <https://www.ti.com/edgeai/projects>



© Copyright 2024 Texas Instruments Incorporated. All rights reserved.

This material is provided strictly “as-is,” for informational purposes only, and without any warranty.
Use of this material is subject to TI’s **Terms of Use**, viewable at [TI.com](https://www.ti.com)

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated