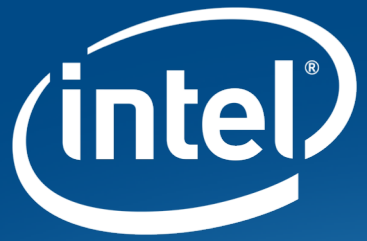

ACCELERATE DEEP LEARNING INFERENCE USING INTEL TECHNOLOGIES

INTRODUCTION: SMART VIDEO

Priyanka Bagade, PhD

Developer Enabler

April 2019

Core and Visual Computing Group

Smart Video Workshop Overview

Introduction

1. Introduction to Intel technologies for deep learning inference
2. Hardware acceleration techniques

Each module contains a hands-on lab exercise that introduces various Intel technologies to accelerate computer vision application with hardware heterogeneity.

Intel® Distribution of OpenVINO™ 101

2. Basic End-to-End Object Detection Example

Hardware Acceleration on laptop and devcloud

3./4./5. Hardware Acceleration with CPU, Integrated GPU, Intel® Movidius™ NCS, FPGA

Optimization

6. Optimization Tools and Techniques

Application

7. Advanced Video Analytics

Edge deployment

8. UP2 AI Vision Development kit as Edge

Optimization Notice

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness or any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice. Notice Revision #20110804.

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No computer system can be absolutely secure.

Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance. Consult other sources of information to evaluate performance as you consider your purchase. For more complete information about performance and benchmark results, visit www.intel.com/performance.

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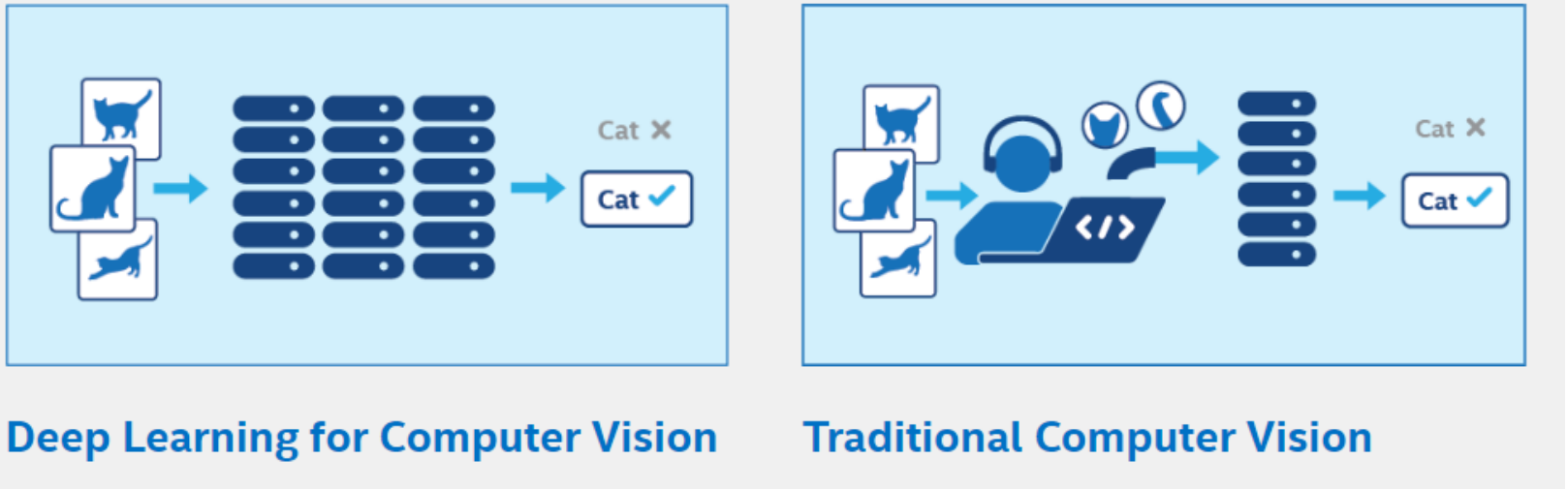
VIDEO: THE "EYE OF IOT"

USE OF VIDEO, COMPUTER VISION AND DEEP LEARNING IS GROWING RAPIDLY

Two types of CV:
Deep Learning vs. Traditional(Conventional)



Deep Learning Computer Vision

- Based on application of a large number of filters to an image to extract features.
- Features in the object(s) are analyzed with the goal of associating each input image with an output node for each type of object.
- Values are assigned to output node representing the probability that the image is the object associated with the output node.

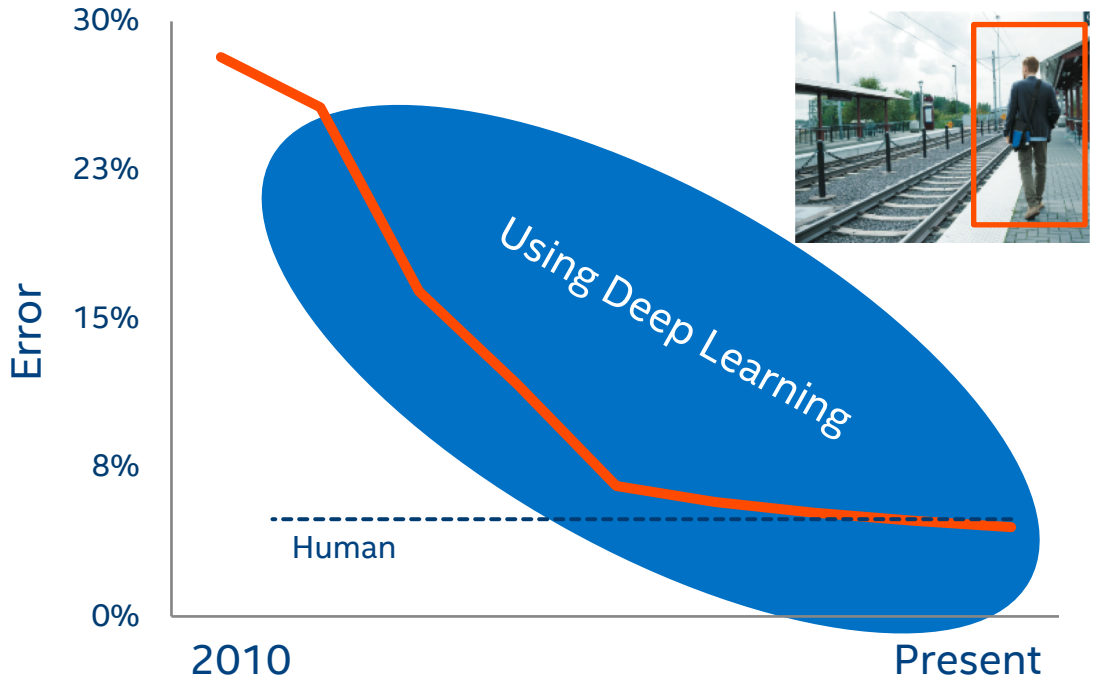
Traditional Computer Vision

- Based on selection and connections of computational filters to abstract key features and correlating them to an object.
- Works well with well defined objects and controlled scene.
- Difficult to predict critical features in larger number of objects or varying scenes.

Deep Learning Usage Is Increasing

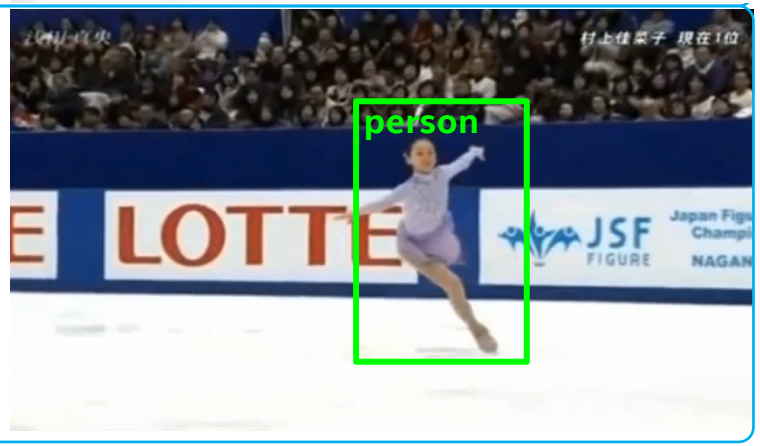
Deep learning revenue is estimated to grow from $655M in 2016 to $35B by 2025[1].

Image Recognition



Traditional Computer Vision
Object Detection

Deep Learning Computer Vision
Person Recognition



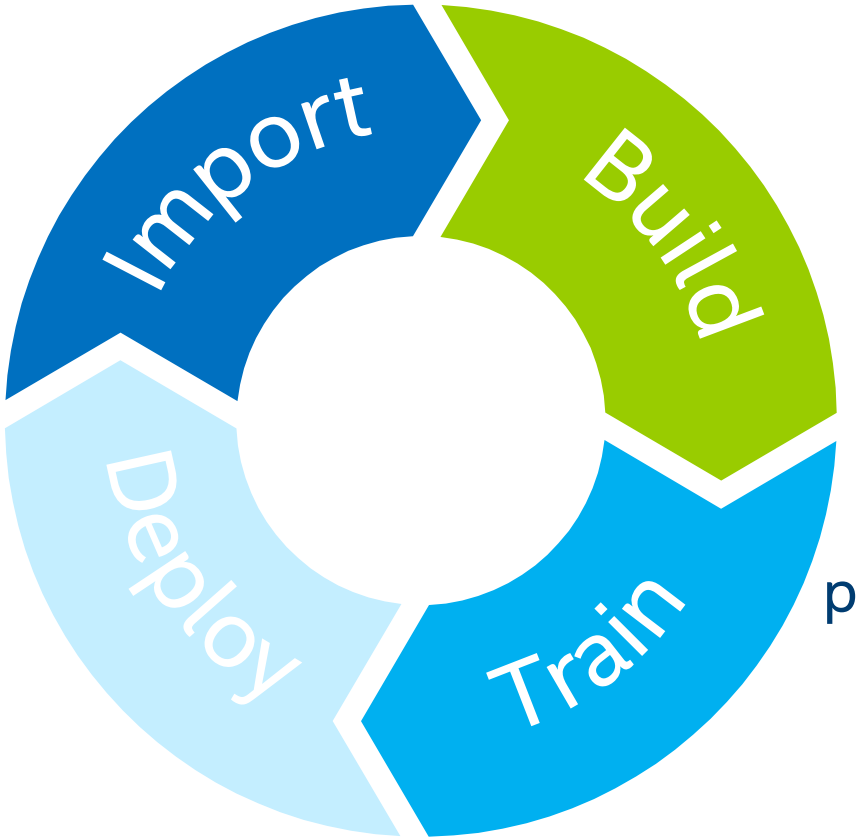
Market Opportunities + Advanced Technologies Have Accelerated Deep Learning Adoption

[1]Tractica* 2Q 2017

Deep Learning Development Cycle

Data aquisition and organization

Create models



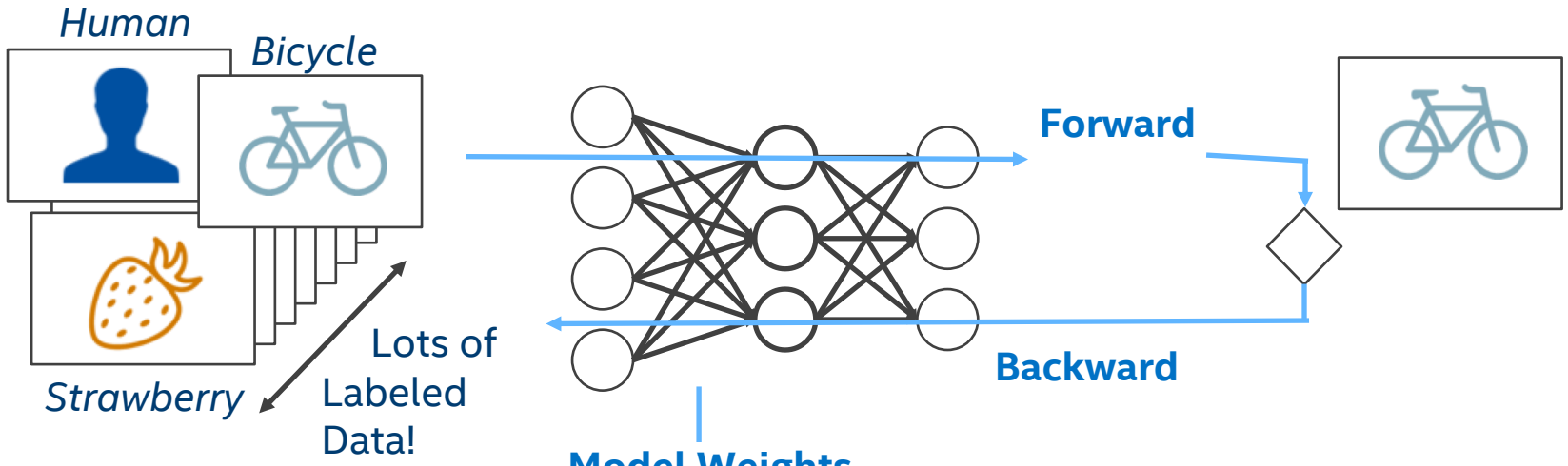
Integrate trained models with application code

Adjust models to meet performance and accuracy objectives

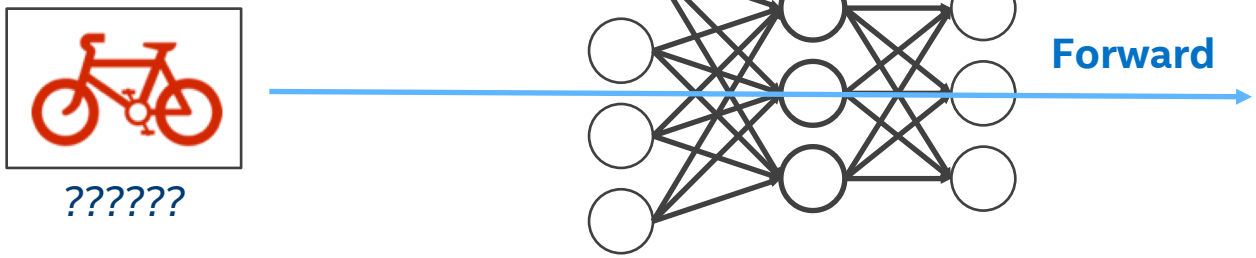
Intel® Distribution OpenVINO™ Toolkit Provides Deployment from Intel® Edge to Cloud

Deep Learning: Training vs. Inference

Training

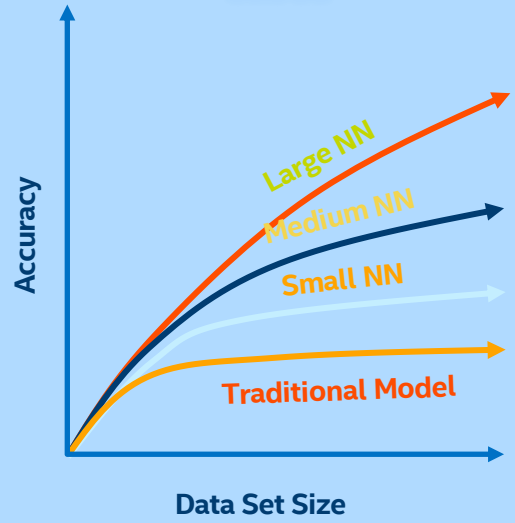


Inference



Did You Know?

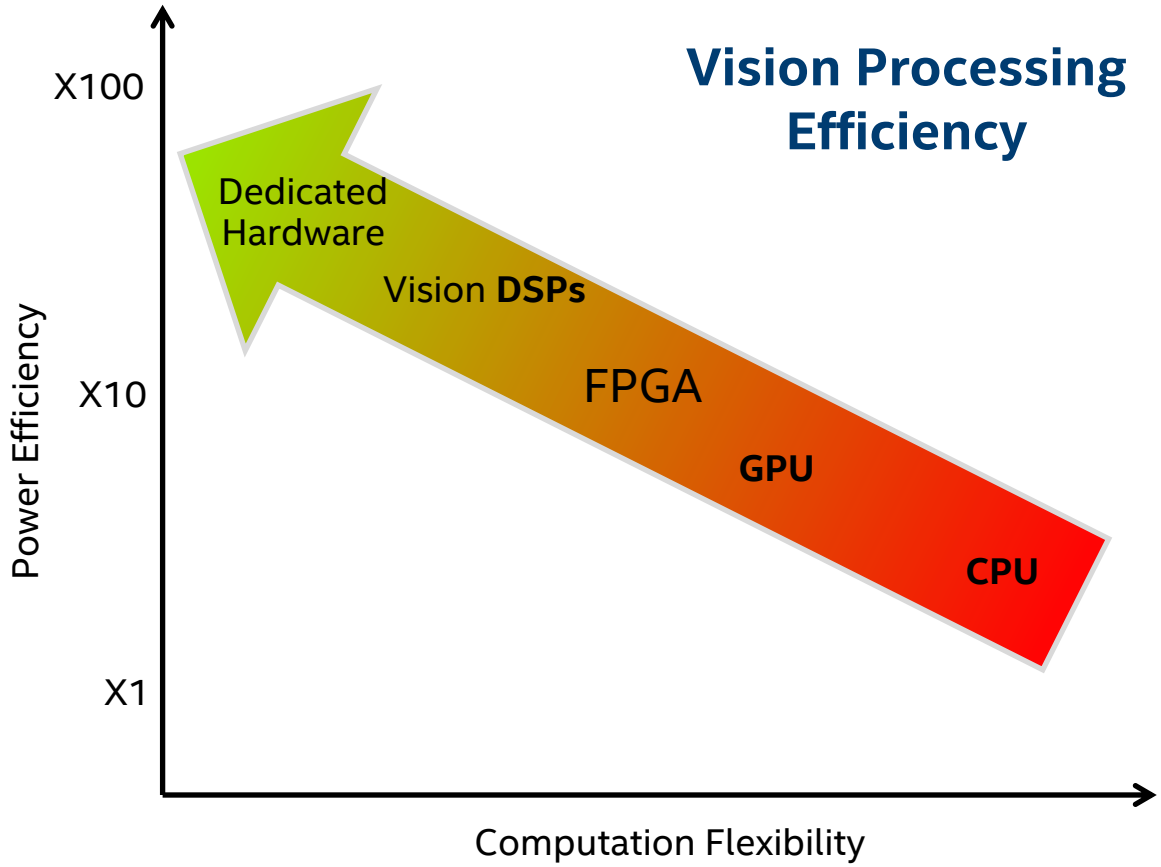
Training requires a very large data set and deep neural network (many layers) to achieve the highest accuracy in most cases



Choosing the “Right” Hardware

Power/Performance Efficiency Varies

- Running the right workload on the right piece of hardware → higher efficiency
- Hardware acceleration is a must
- Heterogeneous computing?



Tradeoffs

- Power/performance
- Price
- Software flexibility, portability

Intel Computer Vision Portfolio

EXPERIENCES

TOOLS

Intel® Parallel Studio XE
Intel® System Studio
Intel® SDK for OpenCL™ Applications
Intel® Media SDK / Media Server Studio
Intel® Distribution of OpenVINO™ toolkit

FRAMEWORKS

Spark MLlib BigDL · TensorFlow · mxnet · theano · neon · Caffe · torch · ONNX

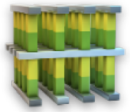
LIBRARIES

Intel® Data Analytics Acceleration Library
Intel® Distribution for python
Intel® Math Kernel Library
Intel® Nervana™ Graph
Movidius Stack
saffron TECHNOLOGY

UNLEASH FULL POTENTIAL

HARDWARE

Compute: Intel Atom, Quark, Core i7, Xeon, Arria 10, Movidius inside



Memory & Storage

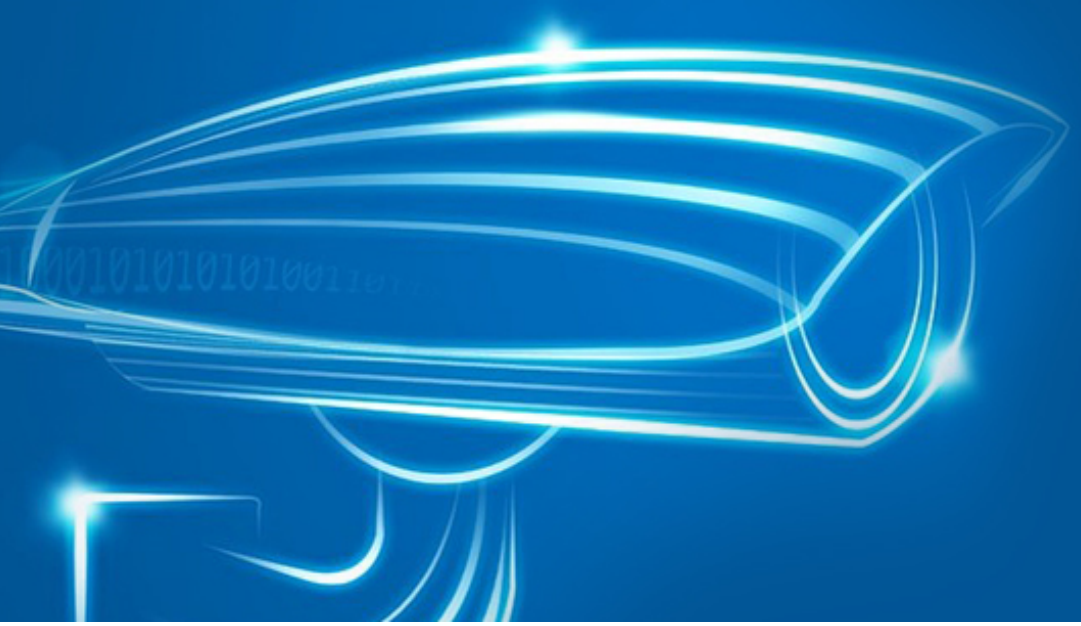
Networking

intel RealSense Technology · intel Movidius™

Visual Intelligence

INTEL® DISTRIBUTION OF OPENVINO™ TOOLKIT

Take your computer vision solutions to a new level with deep learning inference intelligence.



What it is

A toolkit to accelerate development of **high performance computer vision** & **deep learning into vision applications** from device to cloud. It enables deep learning on hardware accelerators and easy deployment across multiple types of Intel® platforms.

Who needs this product?

- Computer vision/deep learning software developers
- Data scientists
- OEMs, ISVs, System Integrators

Usages

Security surveillance, robotics, retail, healthcare, AI, office automation, transportation, non-vision use cases (speech, text) & more.

HIGH PERFORMANCE, PERFORM AI AT THE EDGE

STREAMLINED & OPTIMIZED DEEP LEARNING INFERENCE

HETEROGENEOUS, CROSS-PLATFORM FLEXIBILITY

Free Download ▸ software.intel.com/openvino-toolkit

Open Source version ▸ 01.org/openvinotoolkit

What's Inside Intel® Distribution of OpenVINO™ toolkit

Intel® Deep Learning Deployment Toolkit

Model Optimizer
Convert & Optimize

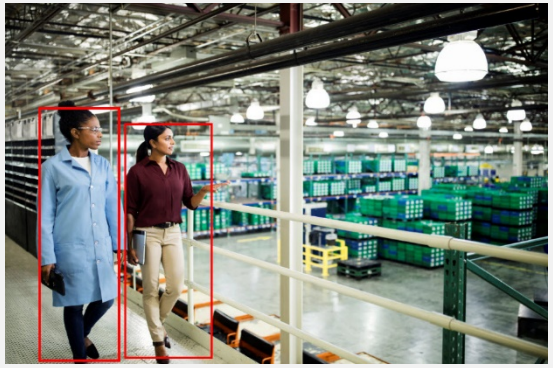
IR

Inference Engine
Optimized Inference

Open Model Zoo
(30+ Pre-trained Models)

Samples

IR = Intermediate Representation file



Traditional Computer Vision

Optimized Libraries & Code Samples

OpenCV*

OpenVX*

Samples

For Intel® CPU & GPU/Intel® Processor Graphics

Tools & Libraries

Increase Media/Video/Graphics Performance

Intel® Media SDK
Open Source version

OpenCL™ Drivers & Runtimes

For GPU/Intel® Processor Graphics

Optimize Intel® FPGA (Linux* only)

FPGA RunTime Environment
(from Intel® FPGA SDK for OpenCL™)

Bitstreams

OS Support: CentOS* 7.4 (64 bit), Ubuntu* 16.04.3 LTS (64 bit), Microsoft Windows* 10 (64 bit), Yocto Project* version Poky Jethro v2.0.3 (64 bit), macOS* 10.13 & 10.14 (64 bit)

Intel® Architecture-Based Platforms Support

Intel® Vision Accelerator Design Products & AI in Production/ Developer Kits

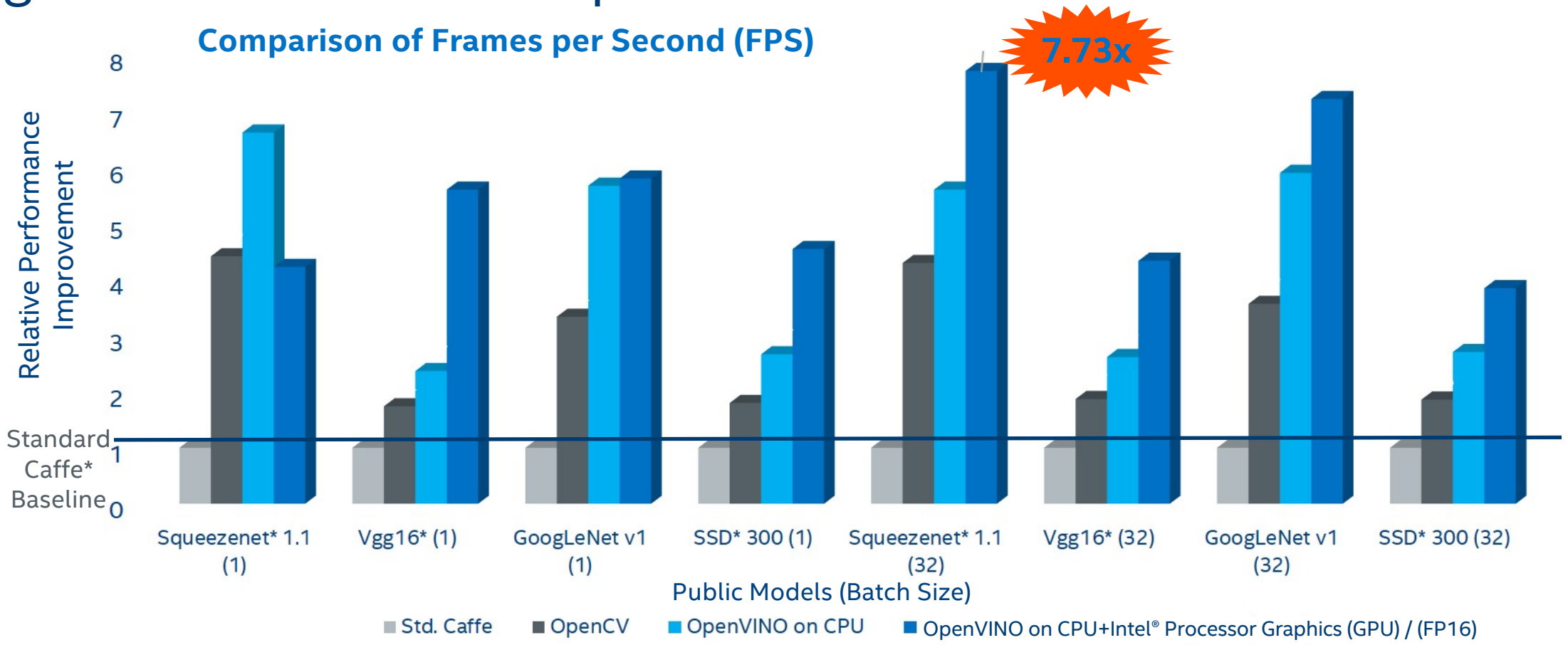
An open source version is available at 01.org/openvinotoolkit (some deep learning functions support Intel CPU/GPU only).

Quick Guide: What's Inside the Intel Distribution vs Open Source version of OpenVINO™ toolkit

Tool/Component	Intel® Distribution of OpenVINO™ toolkit	OpenVINO™ toolkit (open source)	Open Source Directory https://github.com
Installer (including necessary drivers)	✓		
Intel® Deep Learning Deployment toolkit			
Model Optimizer	✓	✓	/opencv/dldt/tree/2018/model-optimizer
Inference Engine	✓	✓	/opencv/dldt/tree/2018/inference-engine
Intel CPU plug-in	✓ Intel® Math Kernel Library (Intel® MKL) only[1]	✓ BLAS, Intel® MKL[1], jit (Intel MKL)	/opencv/dldt/tree/2018/inference-engine
Intel GPU (Intel® Processor Graphics) plug-in	✓	✓	/opencv/dldt/tree/2018/inference-engine
Heterogeneous plug-in	✓	✓	/opencv/dldt/tree/2018/inference-engine
Intel GNA plug-in	✓		
Intel® FPGA plug-in	✓		
Intel® Neural Compute Stick (1 & 2) VPU plug-in	✓		
Intel® Vision Accelerator based on Movidius plug-in	✓		
30+ Pretrained Models - incl. Model Zoo (IR models that run in IE + open sources models)	✓	✓	/opencv/open_model_zoo
Samples (APIs)	✓	✓	/opencv/dldt/tree/2018/inference-engine
Demos	✓	✓	/opencv/open_model_zoo
Traditional Computer Vision			
OpenCV*	✓	✓	/opencv/opencv
OpenVX (with samples)	✓		
Intel® Media SDK	✓	✓[2]	/Intel-Media-SDK/MediaSDK
OpenCL™ Drivers & Runtimes	✓	✓[2]	/intel/compute-runtime
FPGA RunTime Environment, Deep Learning Acceleration & Bitstreams (Linux* only)	✓		

[1]Intel MKL is not open source but does provide the best performance
[2]Refer to readme file for validated versions

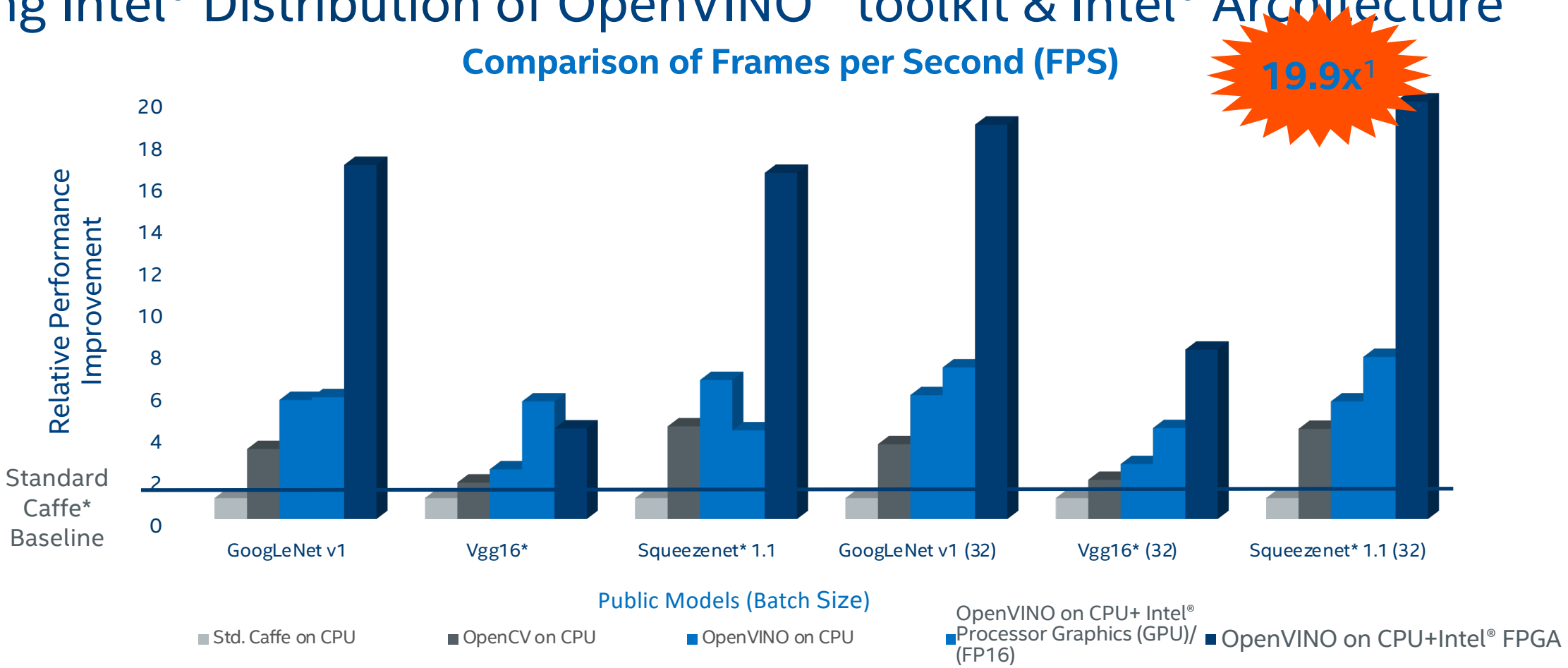
Increase Deep Learning Workload Performance on Public Models using Intel® Distribution of OpenVINO™ toolkit & Intel® Architecture



Fast Results on Intel Hardware, even before using Accelerators

[1]Depending on workload, quality/resolution for FP16 may be marginally impacted. A performance/quality tradeoff from FP32 to FP16 can affect accuracy; customers are encouraged to experiment to find what works best for their situation. The benchmark results reported in this deck may need to be revised as additional testing is conducted. Performance results are based on testing as of April 10, 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.
Configuration: Testing by Intel as of April 10, 2018. Intel® Core™ i7-6700K CPU @ 2.90GHz fixed, GPU GT2 @ 1.00GHz fixed Internal ONLY testing, Test v312.30 – Ubuntu* 16.04, OpenVINO™ 2018 RC4. Tests were based on various parameters such as model used (these are public), batch size, and other factors. Different models can be accelerated with different Intel hardware solutions, yet use the same Intel software tools.

Increase Deep Learning Workload Performance on Public Models using Intel® Distribution of OpenVINO™ toolkit & Intel® Architecture



Get an even Bigger Performance Boost with Intel® FPGA

[1]Depending on workload, quality/resolution for FP16 may be marginally impacted. A performance/quality tradeoff from FP32 to FP16 can affect accuracy; customers are encouraged to experiment to find what works best for their situation. Performance results are based on testing as of June 13, 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks. **Configuration:** Testing by Intel as of June 13, 2018. Intel® Core™ i7-6700K CPU @ 2.90GHz fixed, GPU GT2 @ 1.00GHz fixed Internal ONLY testing, Test v3.15.21 – Ubuntu* 16.04, OpenVINO 2018 RC4, Intel® Arria® 10 FPGA 1150GX. Tests were based on various parameters such as model used (these are public), batch size, and other factors. Different models can be accelerated with different Intel hardware solutions, yet use the same Intel software tools.

Speed Deployment with Pre-trained Models & Samples

Expedite development, accelerate deep learning inference performance, and speed production deployment.

Pretrained Models in Intel® Distribution of OpenVINO™ toolkit

- Age & Gender
- Face Detection–standard & enhanced
- Head Position
- Human Detection–eye-level & high-angle detection
- Detect People, Vehicles & Bikes
- License Plate Detection: small & front facing
- Vehicle Metadata
- Human Pose Estimation
- Action recognition – encoder & decoder
- Text Detection & Recognition
- Vehicle Detection
- Retail Environment
- Pedestrian Detection
- Pedestrian & Vehicle Detection
- Person Attributes Recognition Crossroad
- Emotion Recognition
- Identify Someone from Different Videos–standard & enhanced
- Facial Landmarks
- Gaze estimation
- Identify Roadside objects
- Advanced Roadside Identification
- Person Detection & Action Recognition
- Person Re-identification–ultra small/ultra fast
- Face Re-identification
- Landmarks Regression
- Smart Classroom Use Cases
- Single image Super Resolution (3 models)
- Instance segmentation
- and more…

Binary Models

- Face Detection Binary
- Pedestrian Detection Binary
- Vehicle Detection Binary
- ResNet50 Binary

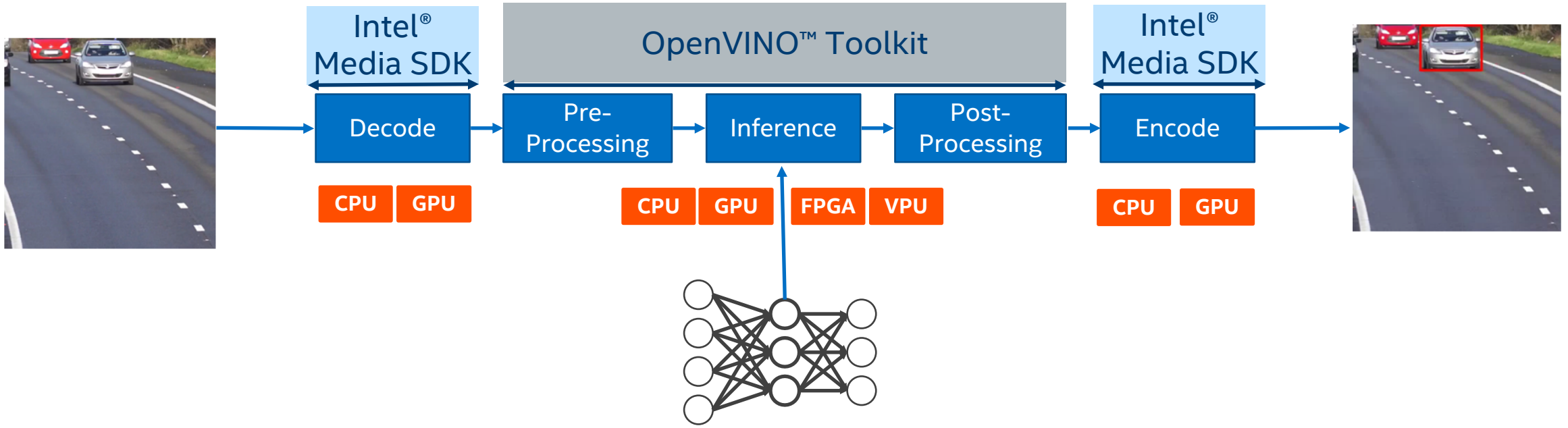
Save Time with Deep Learning Samples

Use Model Optimizer & Inference Engine for public models & Intel pretrained models

- Object Detection
- Standard & Pipelined Image Classification
- Security Barrier
- Object Detection SSD
- Neural Style Transfer
- Hello Infer Classification
- Interactive Face Detection
- Image Segmentation
- Validation Application
- Multi-channel Face Detection
- Object Detection for Single Shot Multibox Detector using Asynch API+

Accelerate Streaming Performance, Integrate Video Analytics Computer Vision Needs Intel® Media SDK

Using Intel® Media SDK and the OpenVINO™ toolkit together enables customers to build high performance, intelligent vision solutions.



Intel® Media SDK

API to Access Intel® Quick Sync Video: Hardware Accelerated Encoding, Decoding, and Processing

- H.265 (HEVC)
- H.264 (AVC)
- MPEG-2 and more
- Resize, scale, deinterlace
- Color conversion, composition
- Denoise, sharpen, and more

Benefits

- Outstanding performance
- Rich API to tune encoding pipeline
- Future proofed: support new processor without code changes

Targeting Digital Security and Surveillance, Connected Car Applications, and More

Smart Camera

Car Infotainment and Cluster Display

using

Intel Atom®, Pentium®, and Celeron® [1]

and

Embedded Linux*

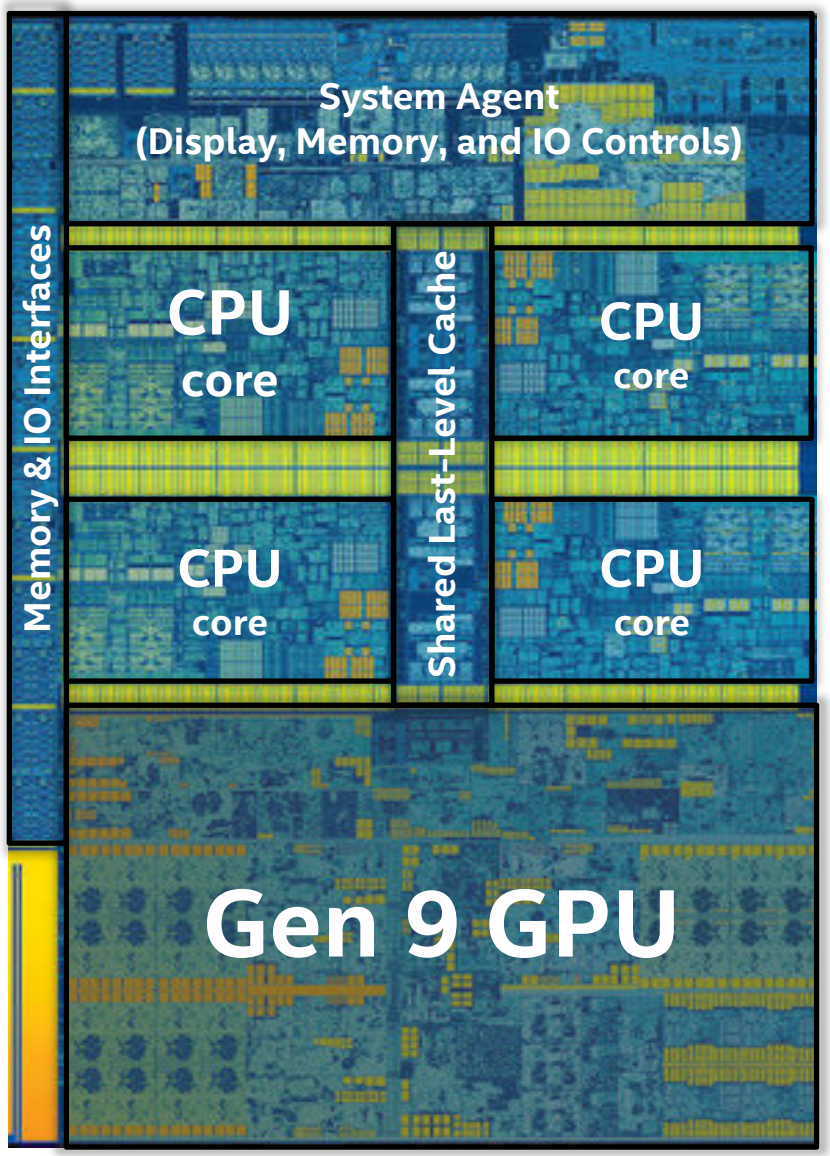
yocto PROJECT

[1] Intel® Celeron® Processor N3350, Intel® Pentium® Processor N4200, Intel Atom® E3930, E3940, E3950 processors

Intel Integrated Graphics

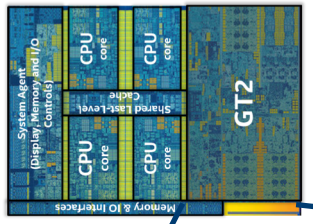
Gen is the internal name for Intel's on-die GPU solution. It's a hardware ingredient with various configurations.

- Intel® Core™ Processors include Gen hardware.
- Gen GPUs can be used for graphics and also as general compute resources.
- Libraries contained in the Intel® Distribution of OpenVINO™ toolkit (and many others) support Gen offload using OpenCL™.



6th Generation Intel® Core™ i7 (Skylake) Processor

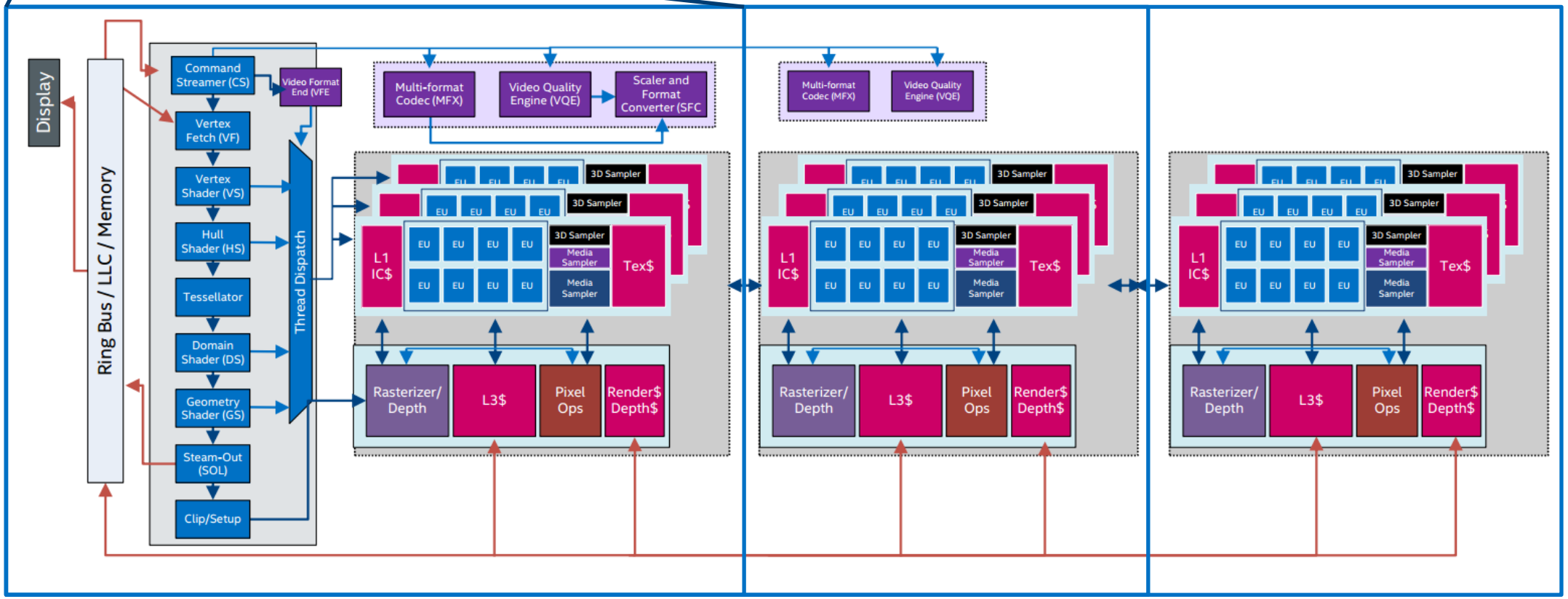
Intel GPU Configurations



GT2
Intel® HD Graphics
24 EUs, 1 MFX

GT3
Intel® Iris® Graphics
48 EUs, 2 MFX

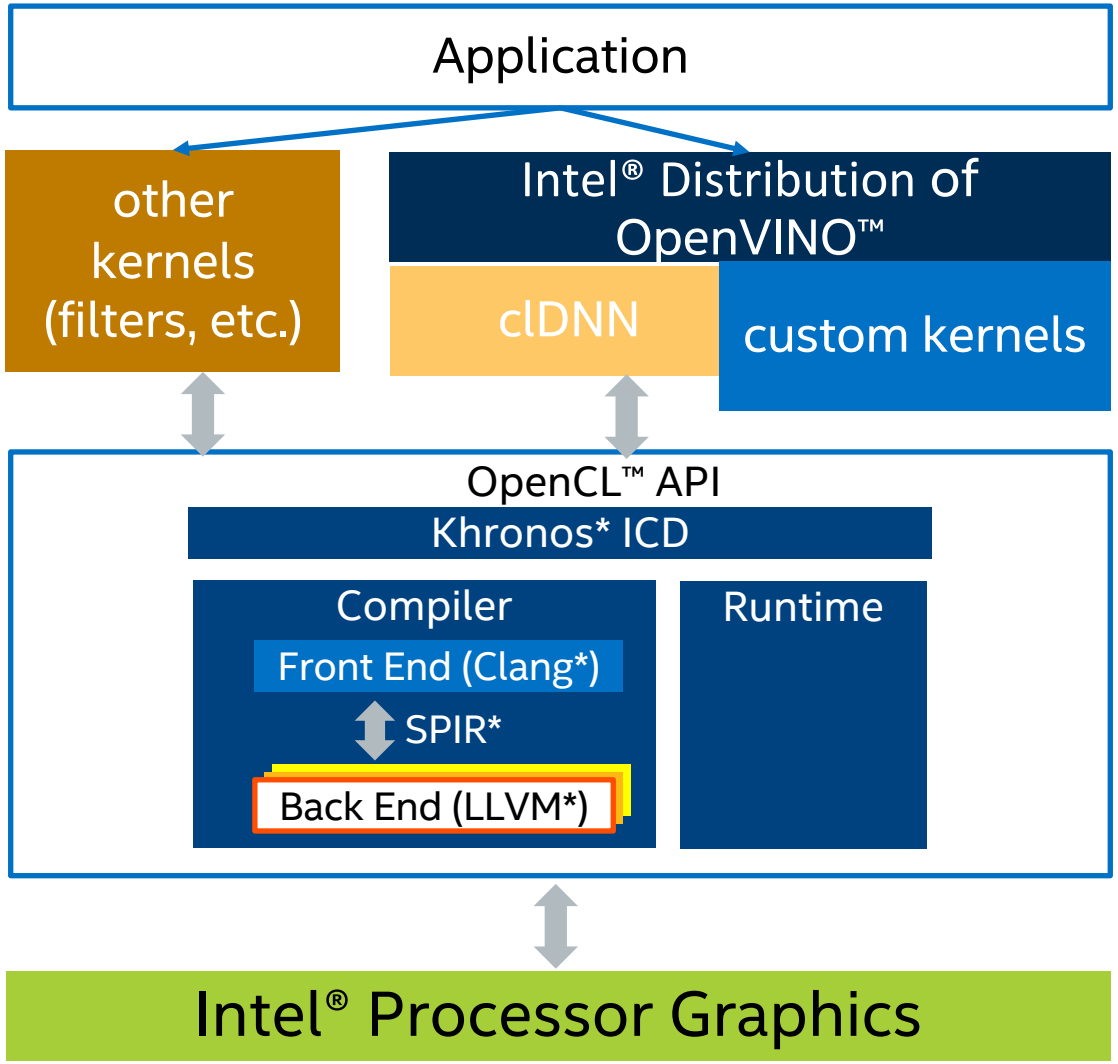
GT4
Intel® Iris® Pro Graphics
72 EUs, 2 MFX



OpenCL™

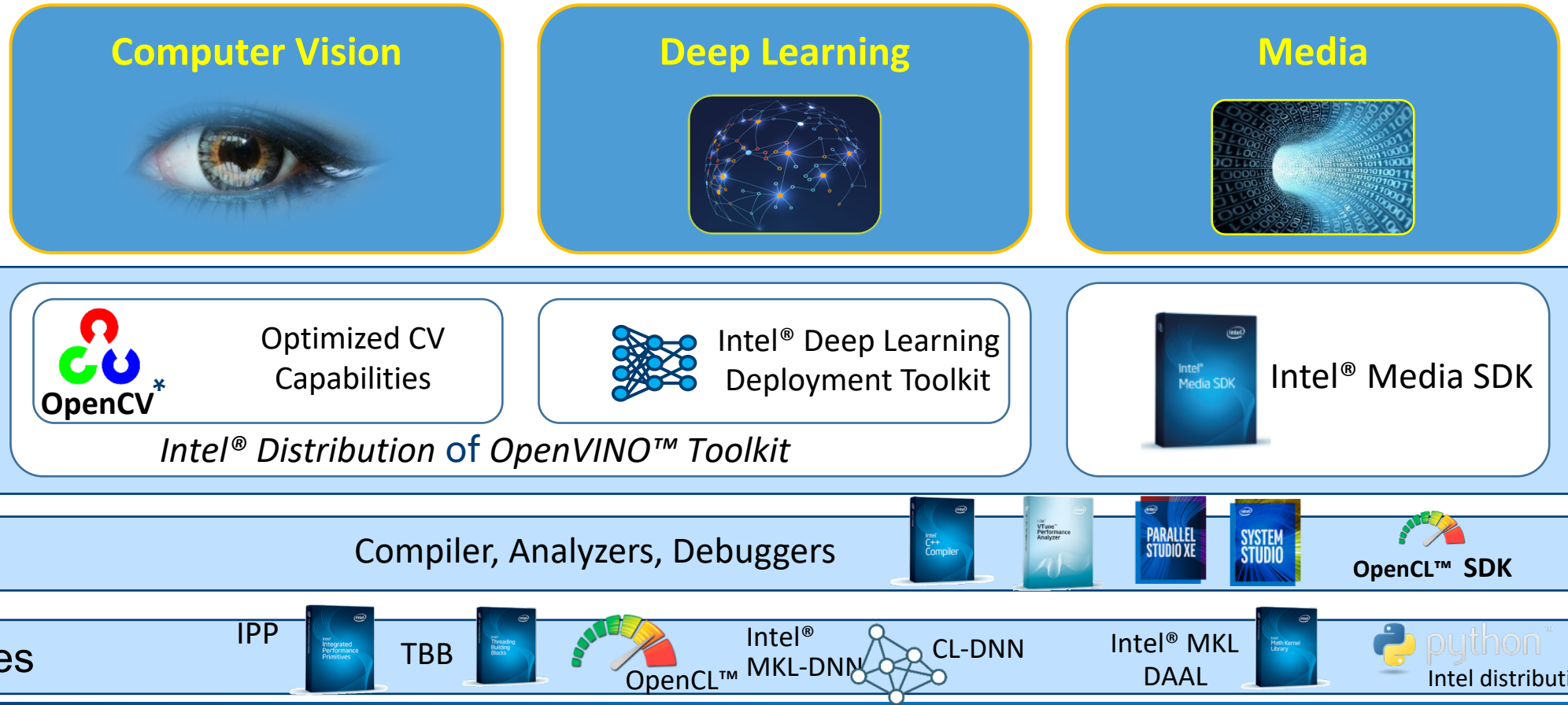
OpenCL™:

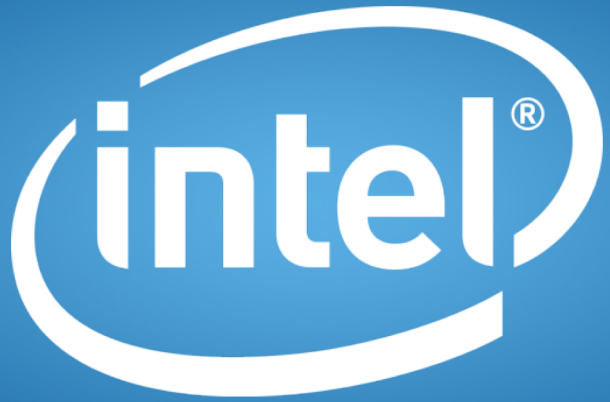
- Required to run with a GPU target (clDNN) using Intel® Processor Graphics
- Custom kernels
- Other kernels can be used for other non-inference pipeline stages, such as color conversions



Putting It All Together

- A major challenge is to get all these tool and libraries to work together in the best possible way to minimize development time and optimize system power/performance.
- A good way to abstract that workload is using an end-to-end pipeline




intel