Autonomous Driving Solutions
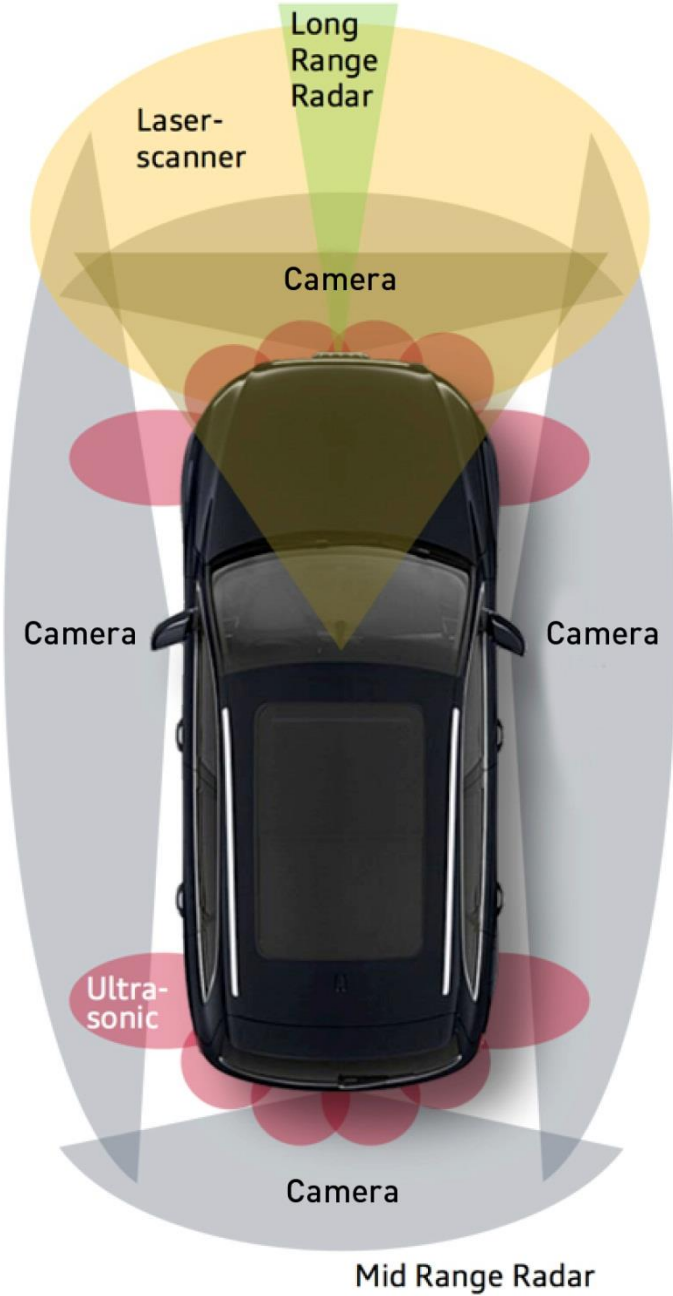
Oct, 2017 | DrivePX2 & DriveWorks

Marcus Oh (moh@nvidia.com)

Sr. Solution Architect, NVIDIA

ADAS & Autonomous Driving

Camera base ADAS Features

Pedestrian Detection
Blind Spot Monitoring
Lane Departure Warning
Park assist

Collision Avoidance
Traffic Sign Recognition
Adaptive Cruise Control
Driver Monitoring

Optical Flow

Histogram

Feature Detection

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Level of Autonomous driving car

Different Levels In a Self Driving Car

LEVEL 0
There are no autonomous features.

LEVEL 1
These cars can handle one task at a time, like automatic braking.

LEVEL 2
These cars would have at least two automated functions.

LEVEL 3
These cars handle "dynamic driving tasks" but might still need intervention.

LEVEL 4
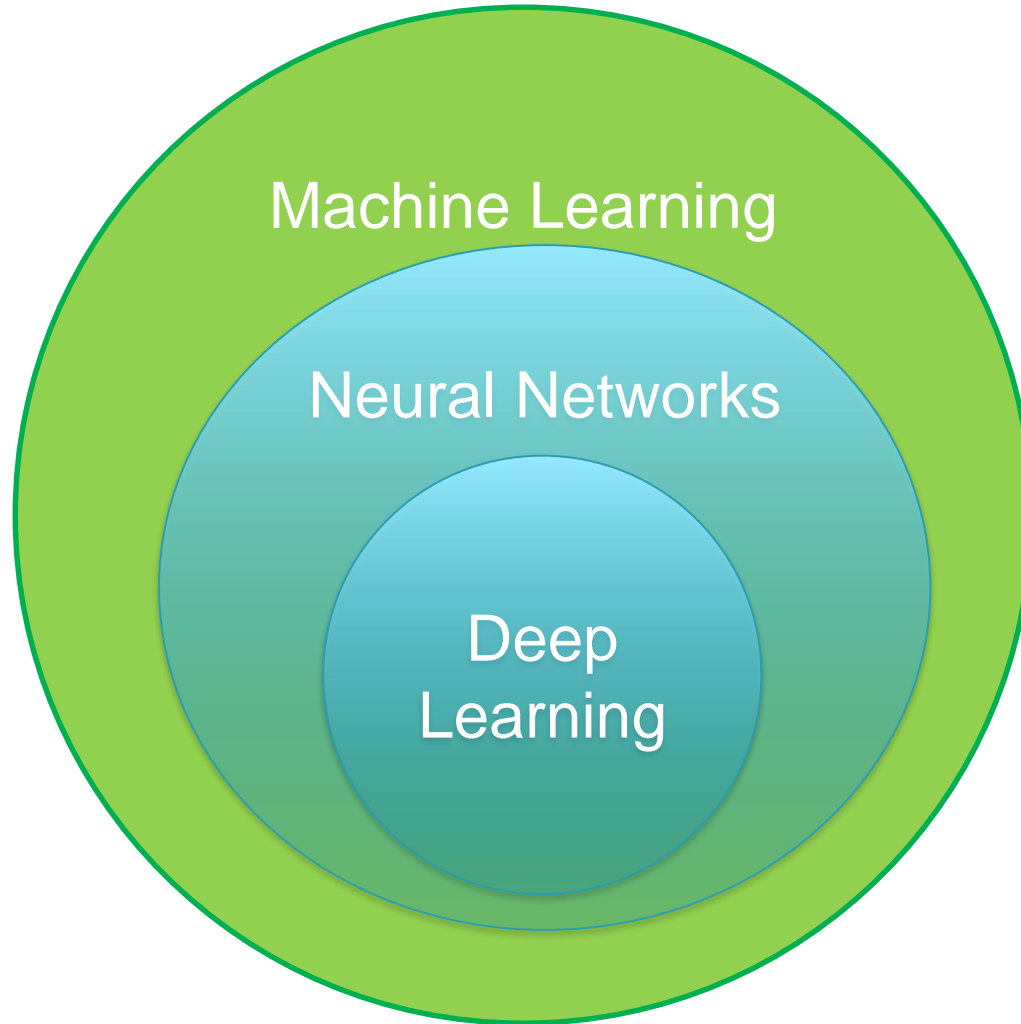These cars are officially driverless in certain environments.
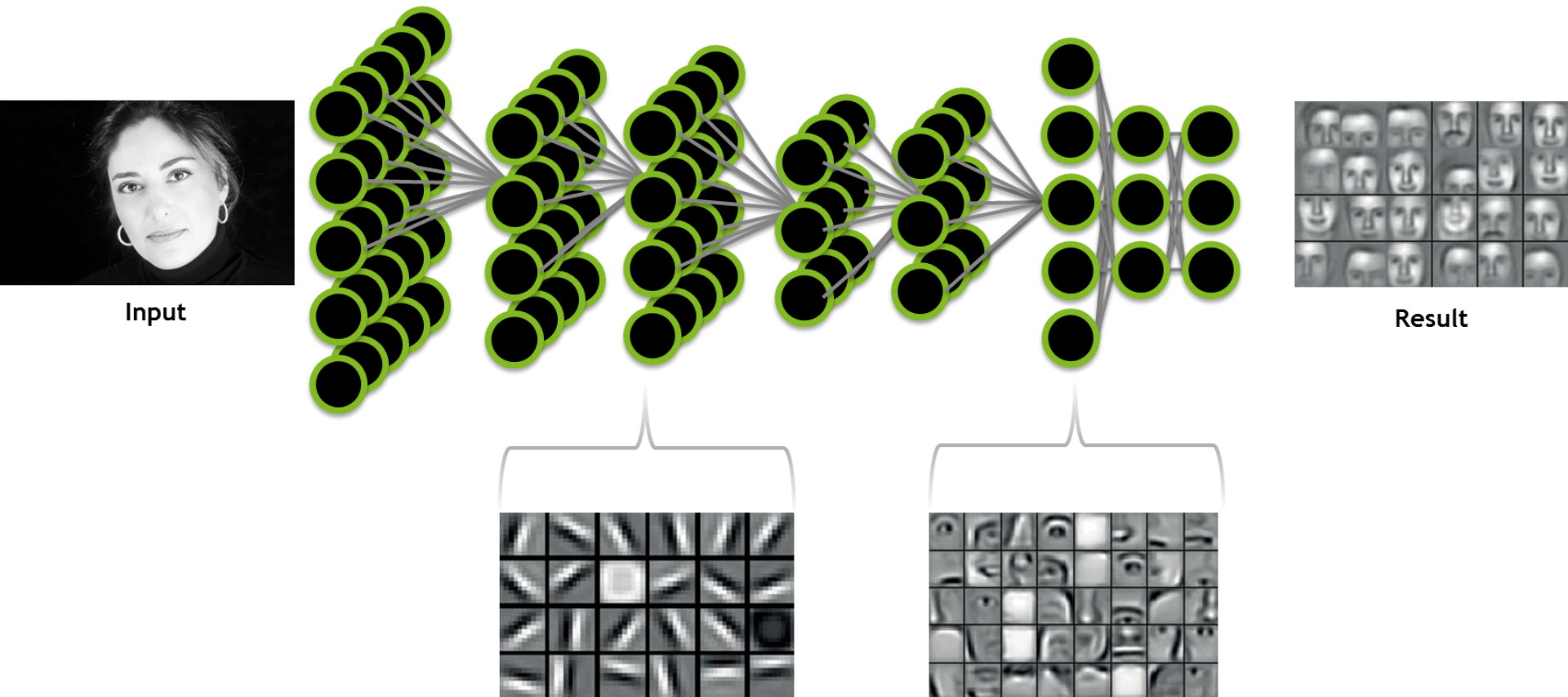
LEVEL 5
These cars can operate entirely on their own without any driver presence.

OodlesTechnologies

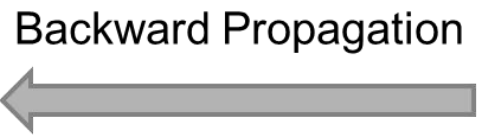www.oodlestechnologies.com

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Deep learning in Autonomous DRIVING

What is DEEP LEARNING?

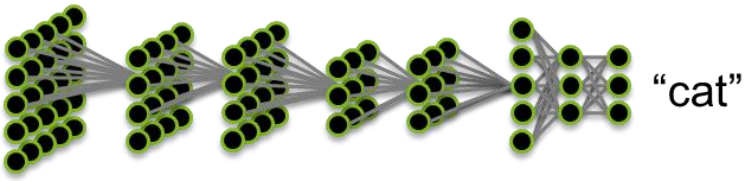

Machine Learning

Neural Networks

Deep Learning

What is DEEP LEARNING?

Input

Result

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Deep Learning Framework

Repeat

Forward Propagation

"turtle"

Backward Propagation
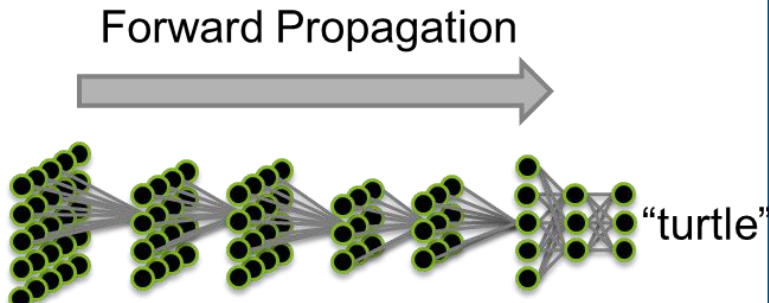
Compute weight update to nudge from "turtle" towards "dog"

Tree
Training

Cat

Dog

Inference

"cat"

Trained Neural Net Model

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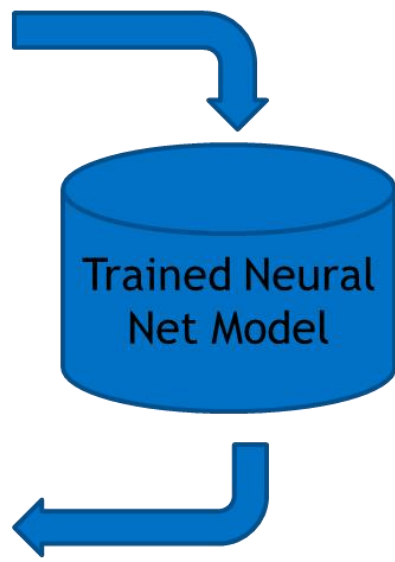
REINFORCEMENT learning
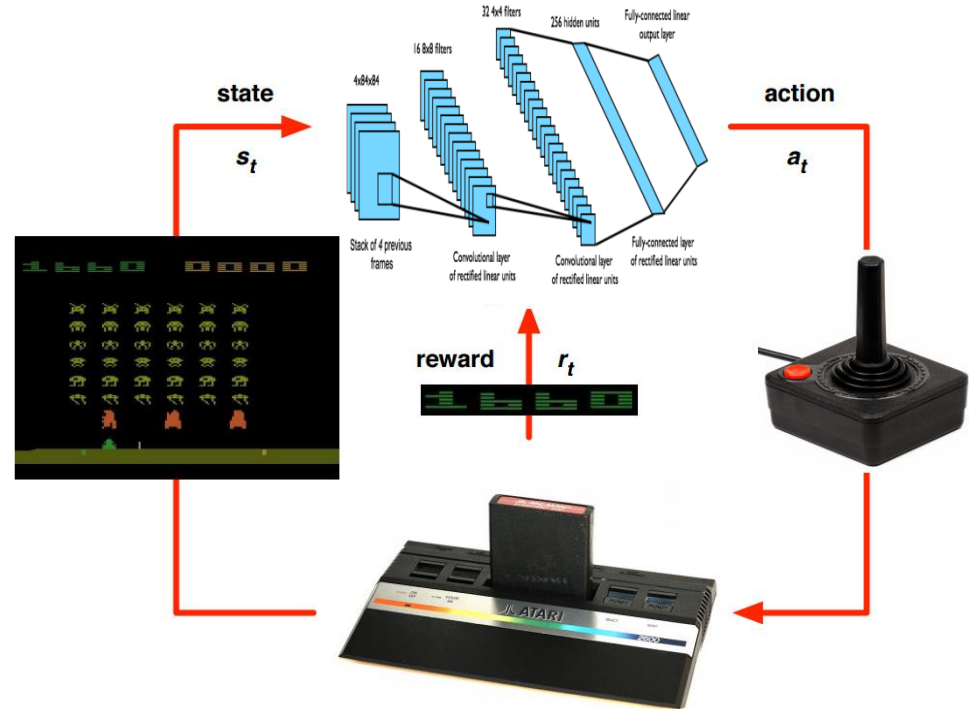
▸ A reinforcement learning agent includes:

  ▸ **state** (environment)
  ▸ **actions** (controls)
  ▸ **reward** (feedback)

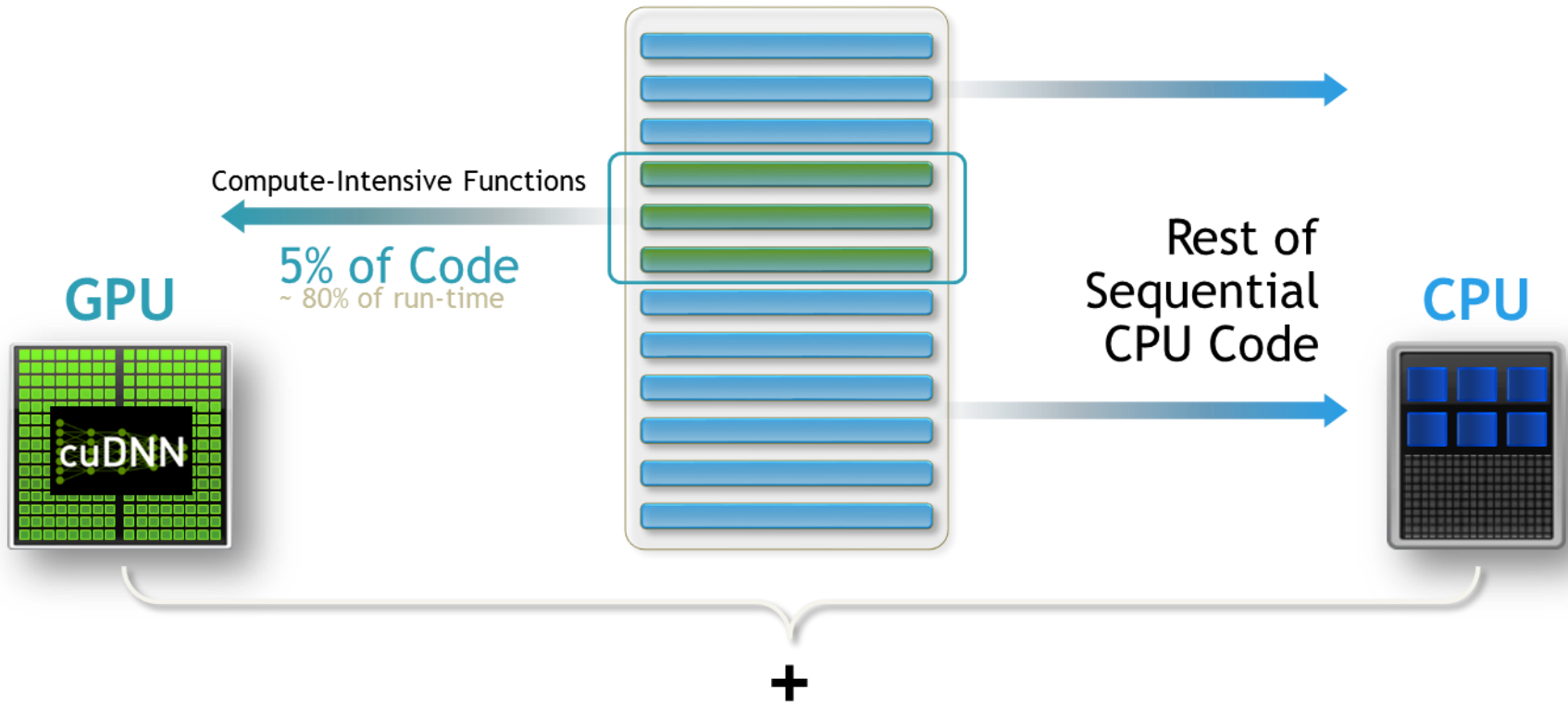▸ A **value function** predicts the future reward of performing actions in the current state

  ▸ Given the recent state, action with the maximum estimated future reward is chosen for execution

▸ For agents with complex state spaces, deep networks are used as **Q-value** approximator
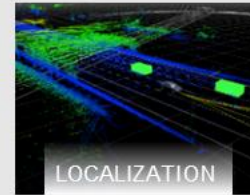
  ▸ inputs

github.com/dusty-nv/jetson-reinforcement

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HOW GPU ACCELERATION WORKS

Compute-Intensive Functions

5% of Code
~ 80% of run-time

GPU

cuDNN

Rest of Sequential CPU Code

CPU

+

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SELF-DRIVING CARS ARE AN AI CHALLENGE

PERCEPTION AI   PERCEPTION AI   LOCALIZATION   DRIVING AI

DEEP LEARNING

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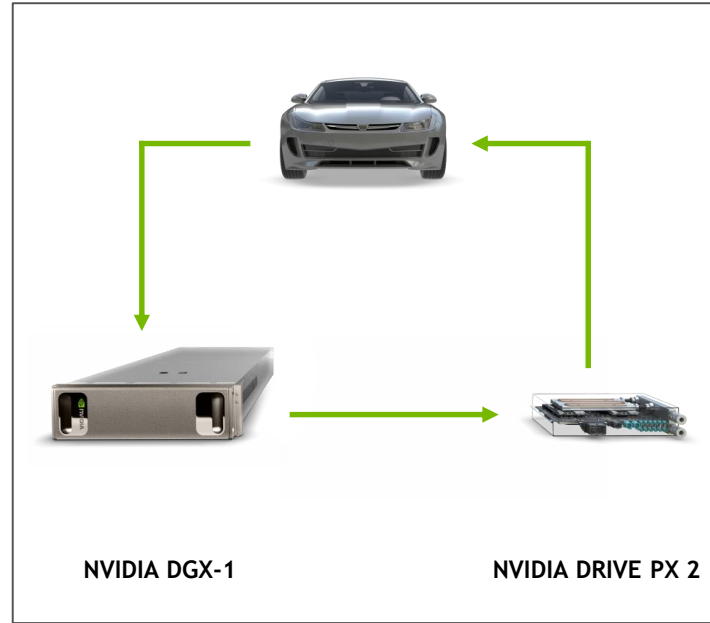# NVIDIA AI SYSTEM
FOR AUTONOMOUS DRIVING
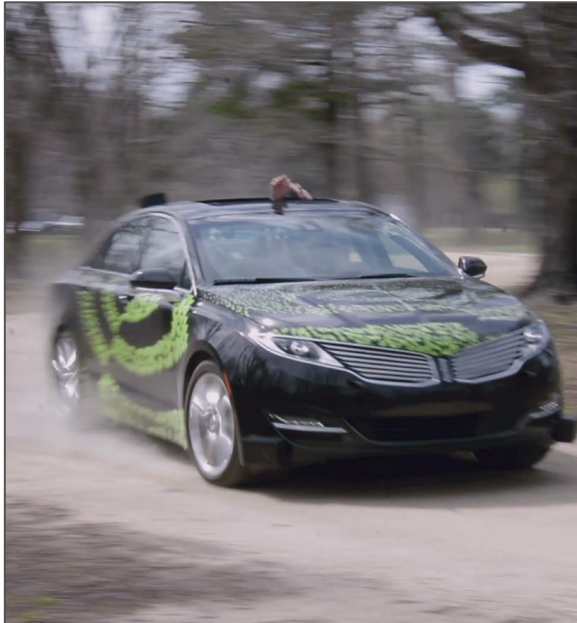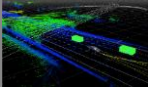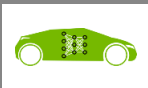
Caffe
CNTK
KALDI
TensorFlow
theano
torch

Training on DGX-1

NVIDIA DGX-1

NVIDIA DRIVE PX 2

MAPPING

LOCALIZATION

DRIVENET

Driving with DriveWorks

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Training Infra & Machine / DIGIT

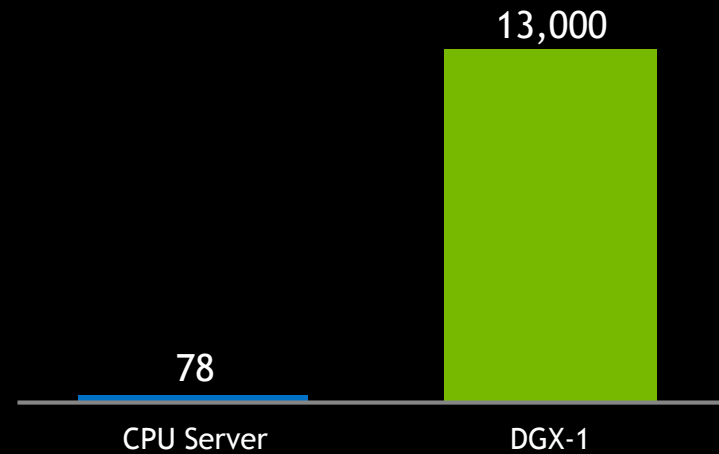# 170X SPEED-UP OVER COTS SERVER
MICROSOFT COGNITIVE TOOLKIT SUPERCHARGED ON NVIDIA DGX-1

8x Tesla P100 | 170TF FP16 | NVLink hybrid cube mesh

170x Faster
(AlexNet images/sec)

13,000

78

CPU Server

DGX-1

AlexNet training batch size 128, Dual Socket E5-2699v4, 44 cores CNTK 2.0b2 for CPU.
CNTK 2.0b3 (to be released) includes cuDNN 5.1.8, NCCL 1.6.1, NVLink enabled

DGX STACK

Fully integrated Analytics and Deep Learning platform

DEEP LEARNING FRAMEWORKS

Caffe   Chainer   Microsoft CNTK

MatConvNet   TensorFlow

theano   torch

NVIDIA DIGITS™

MANAGEMENT
NVIDIA Cloud Management Service

ACCELERATED SOLUTIONS

MAPD   blazegraph   kinetica

Blazing   SCREAM TECHNOLOGIES   graphistry

DEEP LEARNING LIBRARIES
NVIDIA cuDNN and NCCL

CONTAINERIZATION TOOL
NVDocker

GPU DRIVER
NVIDIA GPU Compute Driver Software

SYSTEM
GPU-Optimized Linux Server OS

Instant productivity — plug-and-play, supports every AI framework and accelerated analytics software applications

Performance optimized across the entire stack

Always up-to-date via the cloud

Mixed framework environments — baremetal and containerized

Direct access to NVIDIA experts

DIGIT
Deep Learning GPU Training System

▸ Design, train and visualize deep neural networks for image classification, segmentation and object detection

▸ Download pre-trained models such as AlexNet, GoogLeNet and LeNet from the DIGITS Model Store

▸ Perform hyperparameter sweep of learning rate and batch size for improved model accuracy

▸ Schedule, monitor, and manage neural network training jobs, and analyze accuracy and loss in real time

▸ Import a wide variety of image formats and sources

▸ Scale training jobs across multiple GPUs automatically

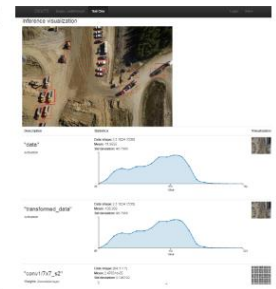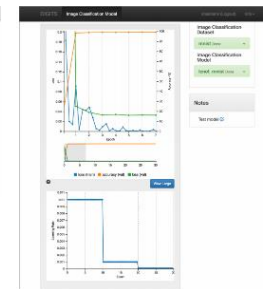Import data for image classification and object detection neural networks
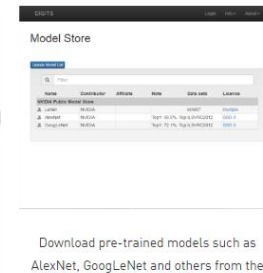
Download pre-trained models such as AlexNet, GoogLeNet and others from the DIGITS Model Store
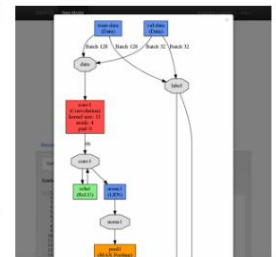
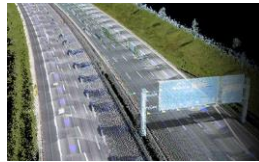Visualize deep neural network architectures

Schedule, monitor, and manage neural network training jobs

NVIDIA SELF-DRIVING BUILDING BLOCKS

Accelerate your development and deployment
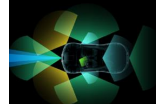
SELF DRIVING TECHNOLOGY

SOFTWARE

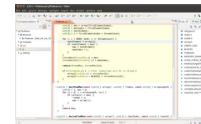| PDK		cuDNN	TensorRT	VPI	DriveWorks

TOOLS

CUDA Development Nsight Eclipse Edition   Tegra System Profiler

HARDWARE

DRIVE PX 2   DRIVE PX 2 AutoCruise   Tegra SOC, dGPU

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DRIVE PX2

NVIDIA DRIVE PX 2 AUTOCRUISE

10W AI Car Computer | Passive Cooling | Automotive IO
Multiple Cameras & Sensors | DriveWorks SW/SDK
AI Highway Driving | Localization & HD Mapping
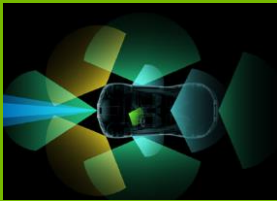Tegra Parker SoC — 1.3 TFLOPS, 6 CPU Cores, Integrated ISP
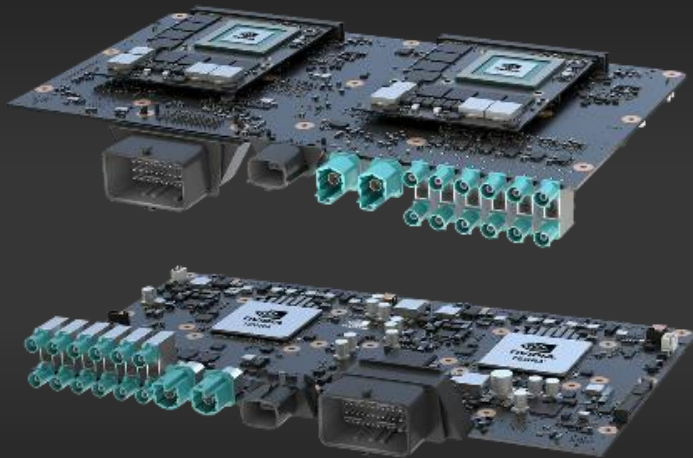
NVIDIA DRIVE PX 2
AUTOCHAUFFEUR & FULLY AUTONOMOUS

Scalable from 1 to 4 Processors to Multiple DRIVE PX 2s
— 2x Tegra Parker SoC, 2x Pascal dGPU, 8 TFLOPS, 24 DNN TOPs
Up to 12 Cameras; plus LIDAR, Radar, Ultrasonic sensors
DriveWorks SW/SDK | AI Perception | Localization & Mapping

DriveWorks

DRIVEWORKS

Software Development Kit (SDK) for Autonomous Driving

Process sensor data through Perception, Mapping, Localization, and Path Planning steps

Provides a rich set of functionalities:

- Sensor Abstraction Layer (SAL)

- Algorithm Modules, DNNs

- Applications

- Tools for sensor setup and management

Flexible, modular and optimized for GPU

Runs on top of OS, CUDA/CuDNN, TensorRT, VPI

SOFTWARE STACK WITH DRIVEWORKS
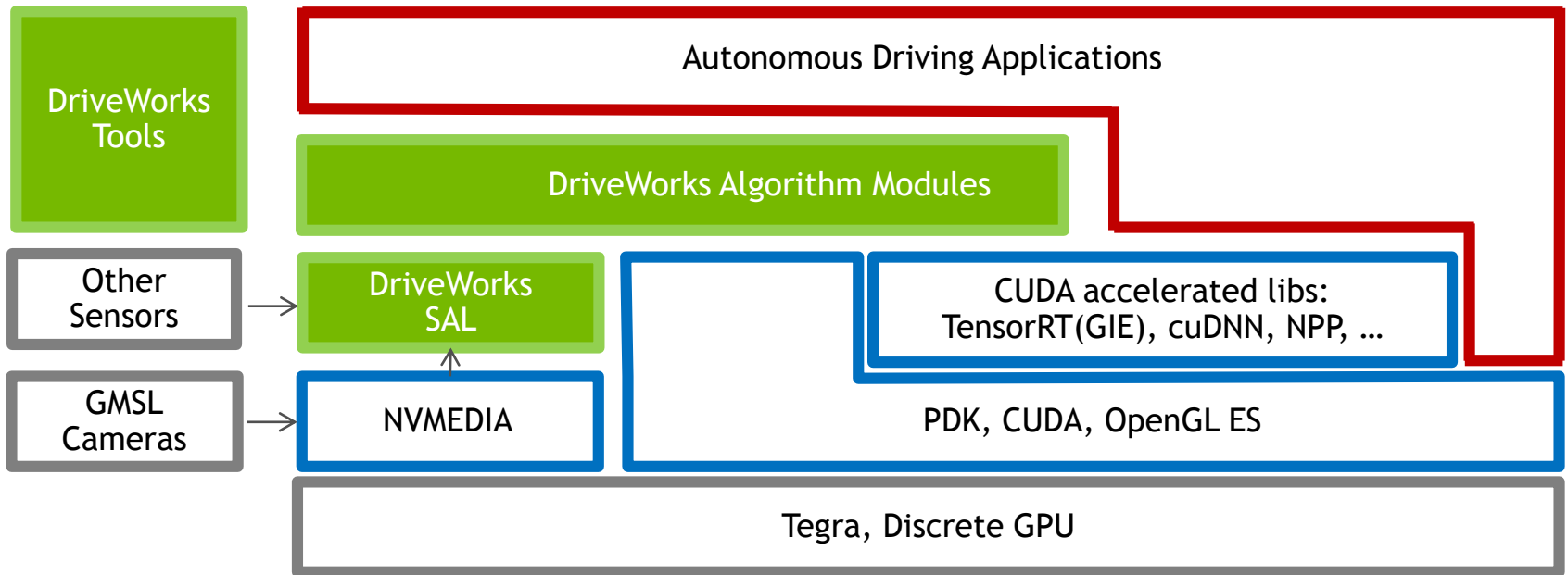
DRIVEWORKS PROCESSING PIPELINE
End-to-End processing for Autonomous Driving

Cameras

LIDAR

Radar

Other Sensors

SAL

PERCEPTION
- Sensor Fusion
- Detection
- Segmentation

LOCALIZATION
- HD Map Interface
- Landmarks
- Localization

PLANNING
- Traffic Prediction
- Occupancy Grid
- Trajectory
- Path Planning

PilotNet

NVIDIA System Software

Visualization

Actuators

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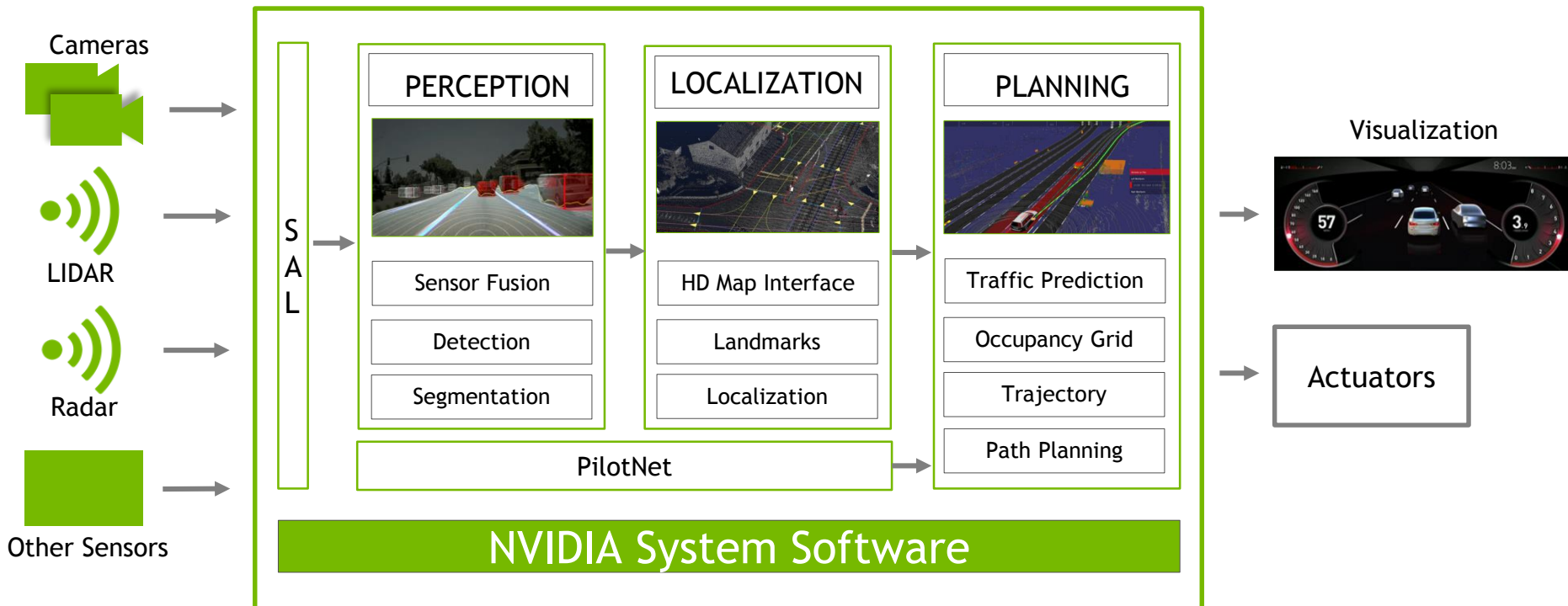
DEEP NEURAL NETWORKS IN DRIVEWORKS

DriveNet

Multi-class detection: Cars, Pedestrian, Bicycles
Upcoming: Lanes, Traffic signs

LaneNet

Lane detection

OpenRoadNet

Free space detection

PilotNet

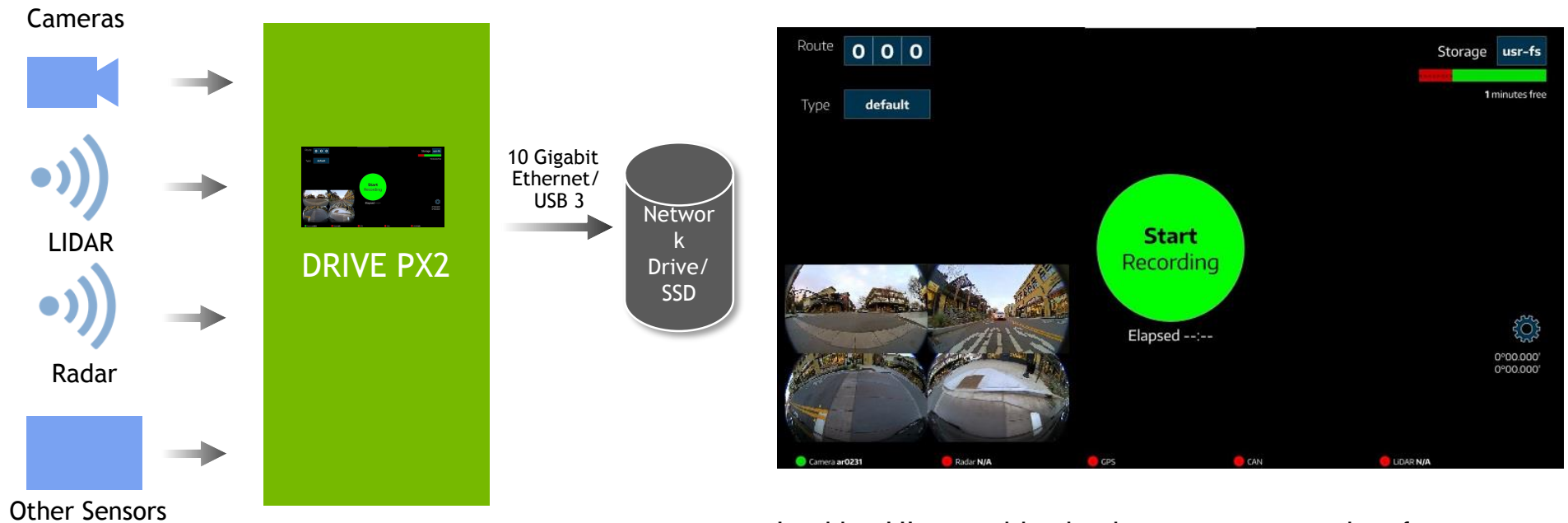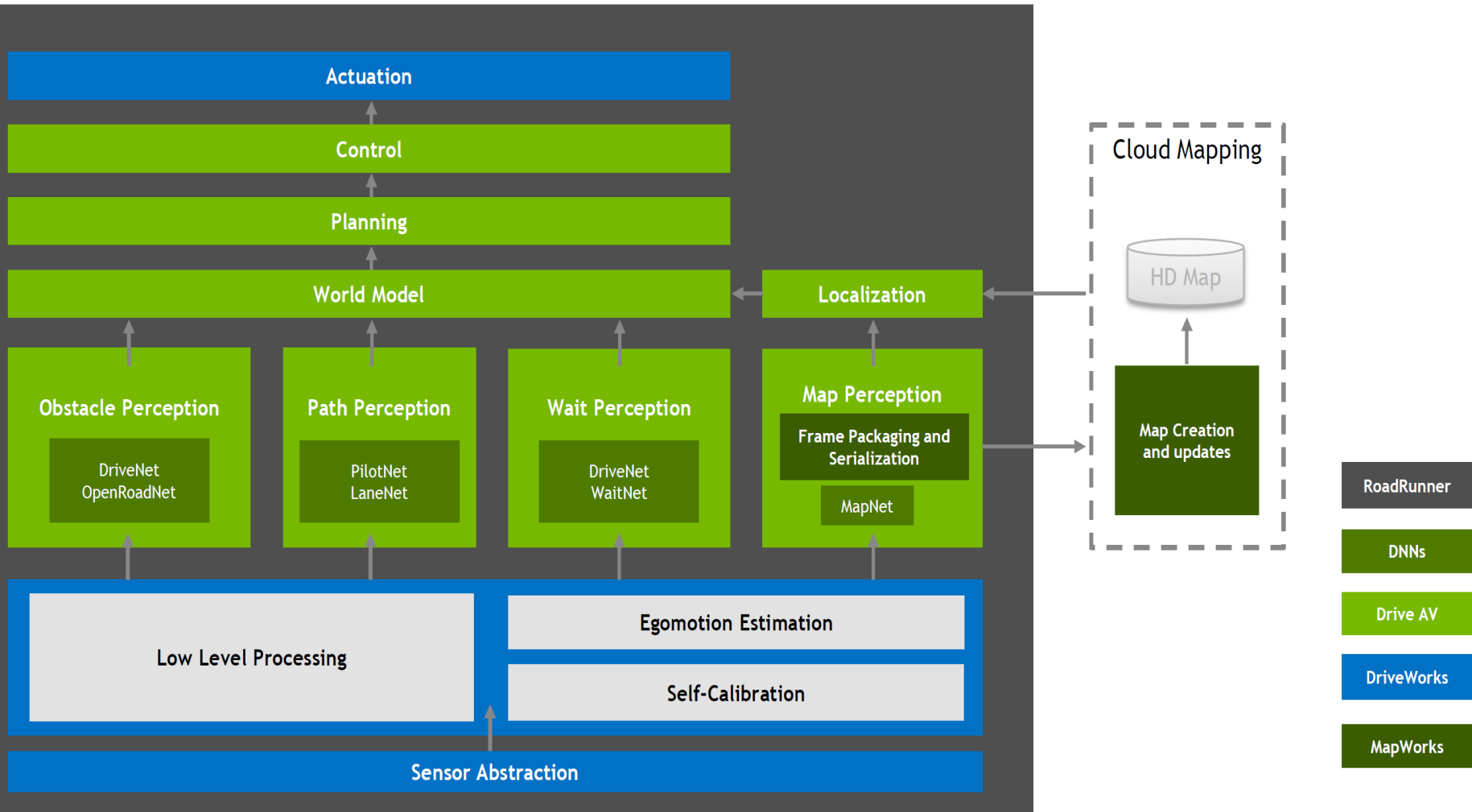End to end in-lane driving

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NVIDIA DEVELOPER TOOLCHAIN

DriveInstall

Easy installation

Devkit flashing

Sets up development environment

NVIDIA® Nsight™ Eclipse Edition

CUDA build management

CUDA kernel debugging and profiling

CPU and GPU debugging

Memory checker

Tegra System Profiler

CPU sampling profiler

Application Trace

CUDA API & GPU trace

OpenGL ES API & GPU trace

Code decoration API/NVTX

Tegra Graphics Debugger

Performance monitoring

Frame debugging

Frame profiling

GENIVI®

TOOLS - DATA ACQUISITION

Cameras

LIDAR

Radar

Other Sensors

DRIVE PX2

10 Gigabit Ethernet/ USB 3

Network Drive/ SSD

Intuitive UI to enable simultaneous capture data from sensors
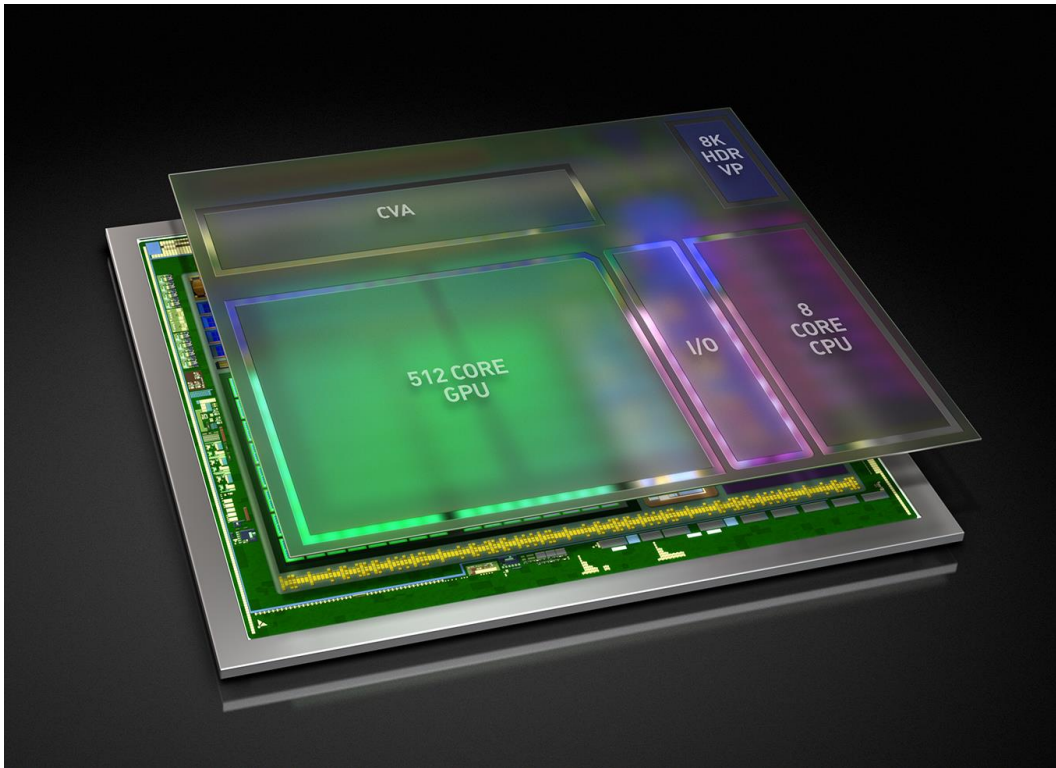
HIGH LEVEL ARCHITECTURE

NEXT GENERATION AD SOLUTION

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INTRODUCING XAVIER
AI SUPERCOMPUTER SOC
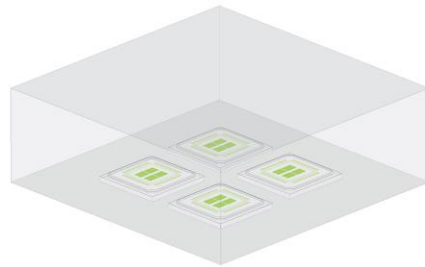

7 Billion Transistors 16nm FF

8 Core Custom ARM64 CPU

512 Core Volta GPU

New Computer Vision Accelerator

Dual 8K HDR Video Processors

Designed for ASIL C Functional Safety

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THE NEXT GENERATION
DRIVE PX 2 IS THE TIME MACHINE TO XAVIER

Today

PASCAL GENERATION

Next

VOLTA GENERATION

XAVIER

2x PARKER + 2x PASCAL

GENIVI®

INTRODUCING XAVIER
AI SUPERCOMPUTER SOC

ONE ARCHITECTURE
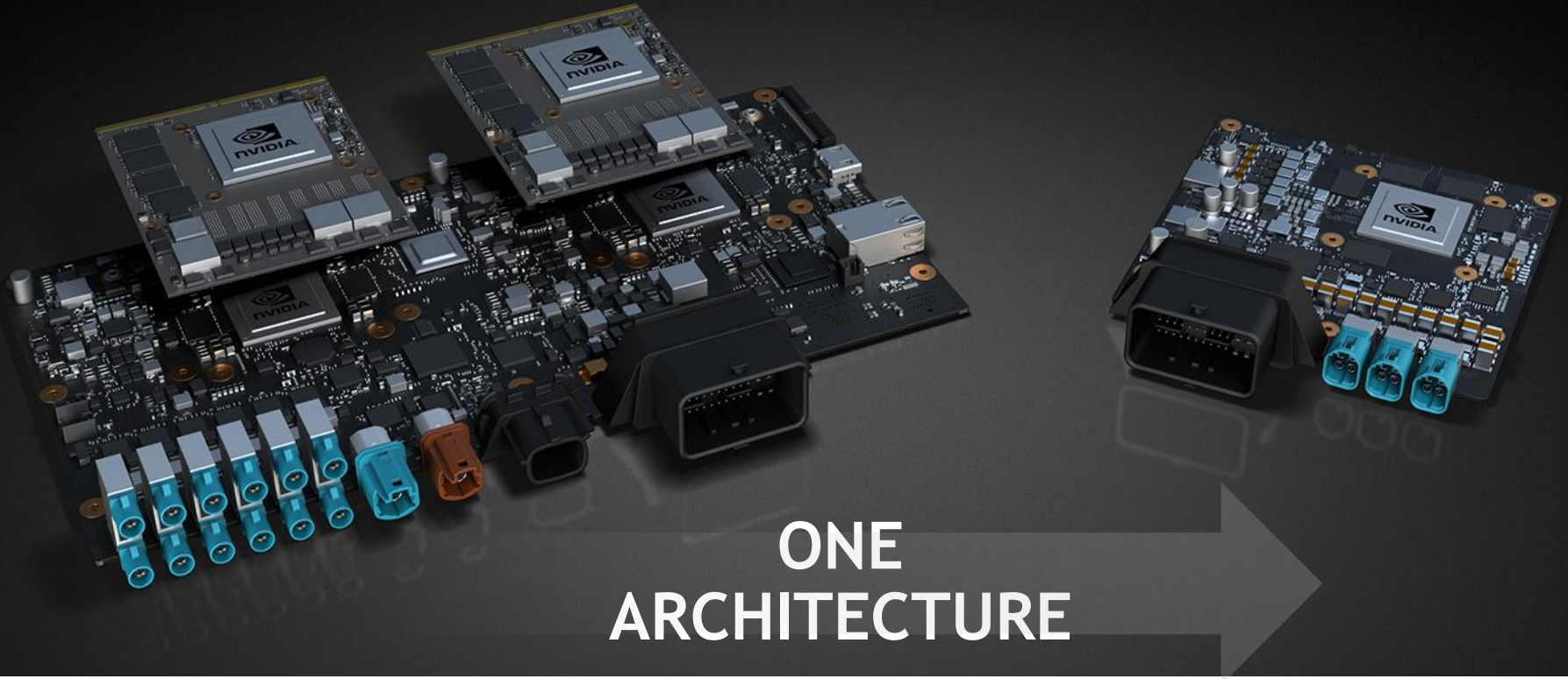
DRIVE PX 2
2 PARKER + 2 PASCAL GPU | 20 TOPS DL | 120 SPECINT | 80W

XAVIER
20 TOPS DL | 160 SPECINT | 20W

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Thank you!

Visit GENIVI at http://www.genivi.org or http://projects.genivi.org

Contact us: help@genivi.org

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