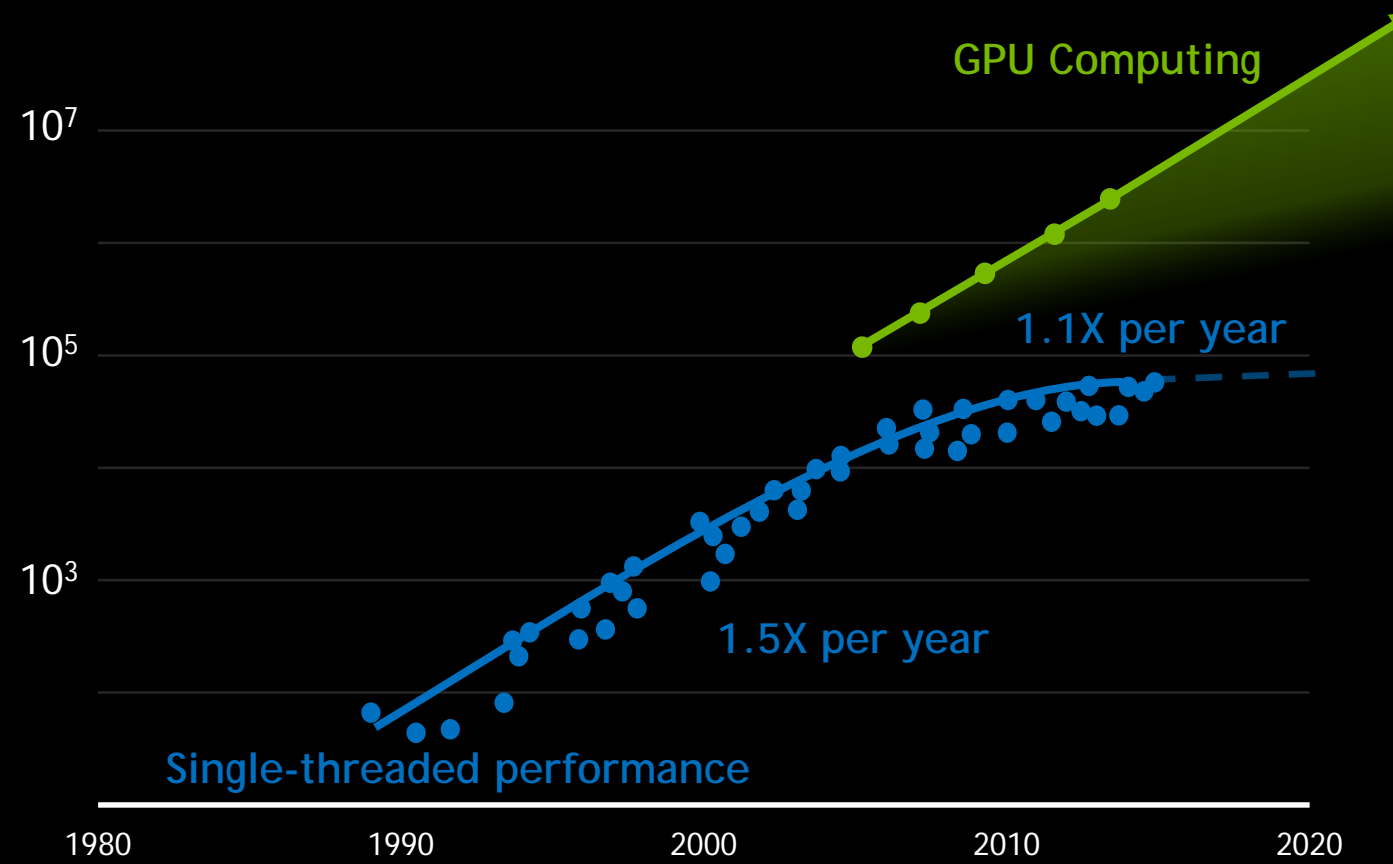




# AI IN THE CLOUD AND IN THE CAR

Sanford Russell

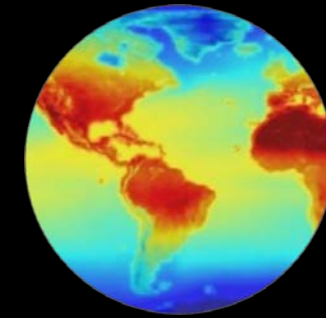
# THE RISE OF GPU COMPUTING



40 Years of Computing Performance



Healthcare



Weather Simulation



Oil & Gas



Retail

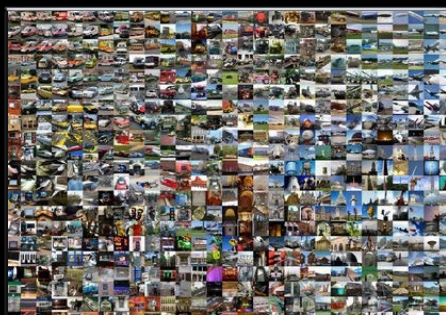


Self-driving Cars

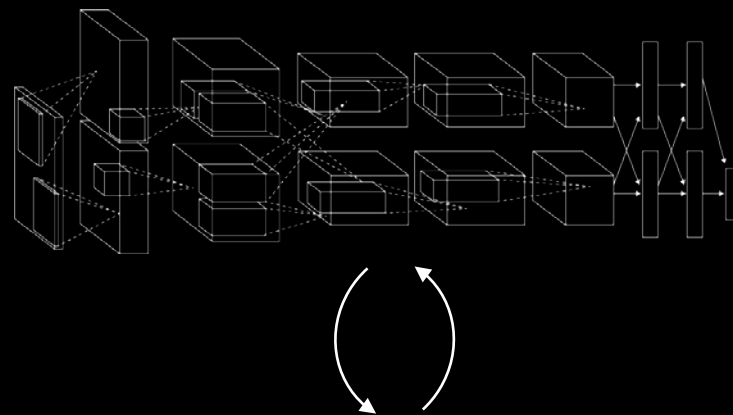
Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten New plot and data collected for 2010-2015 by K. Rupp

# COMPUTERS WRITING SOFTWARE

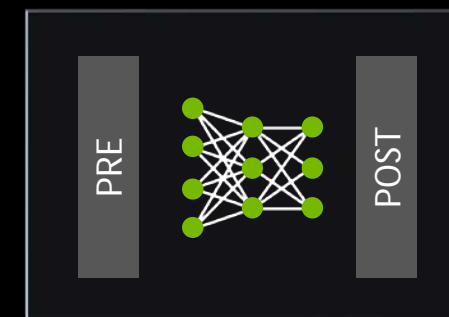
DATA



DEEP NEURAL NETWORK



PROGRAM



# AMAZING SOFTWARE



COLORIZING IMAGES  
UC Berkeley

# AMAZING SOFTWARE



COLORIZING IMAGES  
UC Berkeley



SEGMENTATION  
NVIDIA

# AMAZING SOFTWARE



COLORIZING IMAGES

UC Berkeley



SEGMENTATION

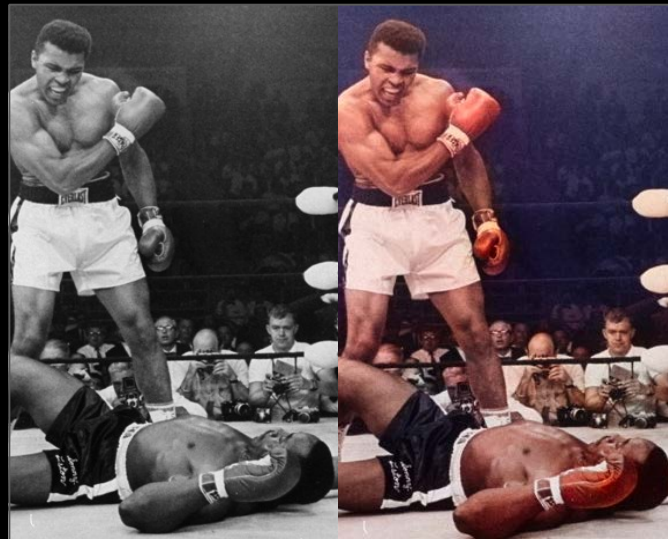
NVIDIA



COLORIZING HAIR

L'Oréal

# AMAZING SOFTWARE



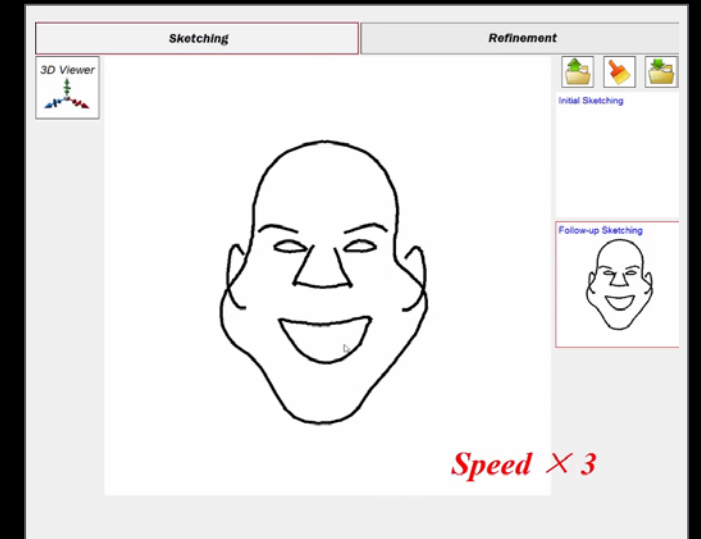
COLORIZING IMAGES  
UC Berkeley



SEGMENTATION  
NVIDIA



COLORIZING HAIR  
L'Oréal



SKETCH TO FACE  
The University of Hong Kong

# MANY THINGS TO LEARN



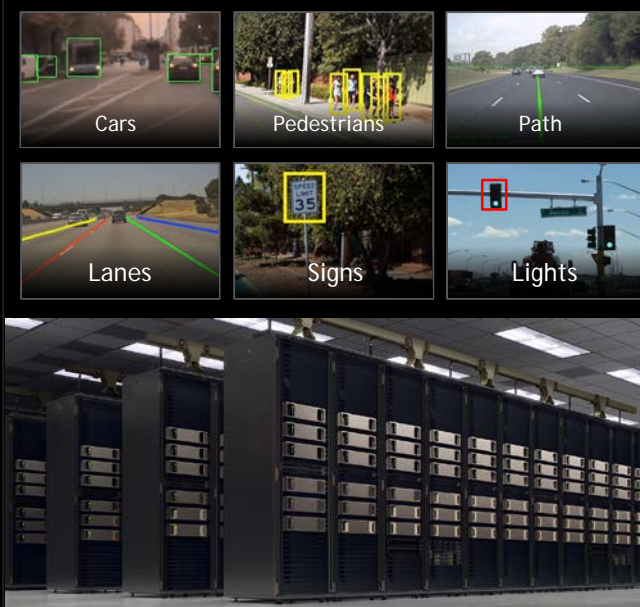


# AV REQUIRES AN END-TO-END PLATFORM

## COLLECT DATA



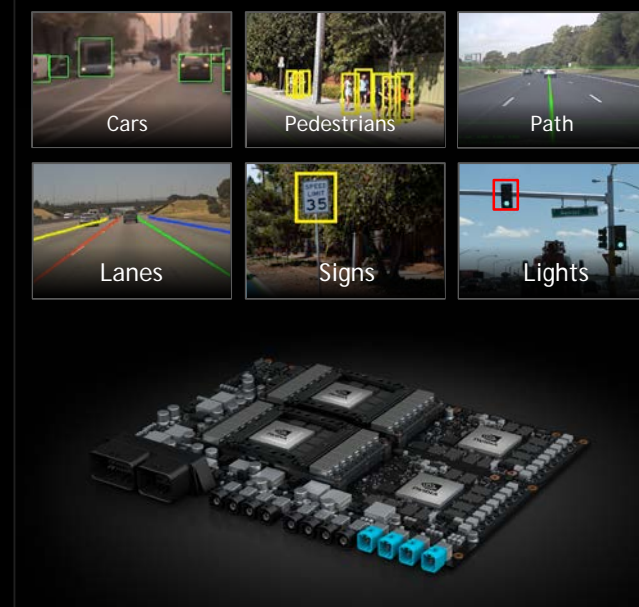
## TRAIN MODELS



## SIMULATE



## DRIVE



# MANY SIMULTANEOUS DNNs



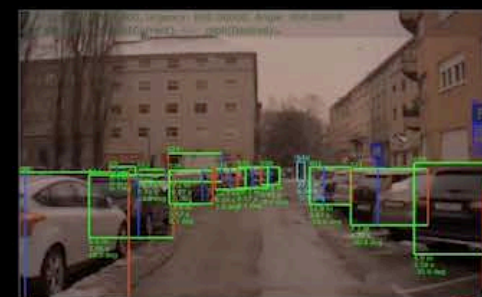
Perception



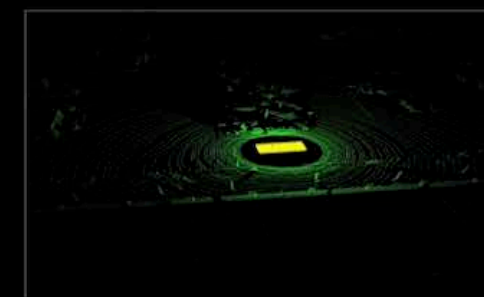
Free Space Perception



Distance Perception



Weather



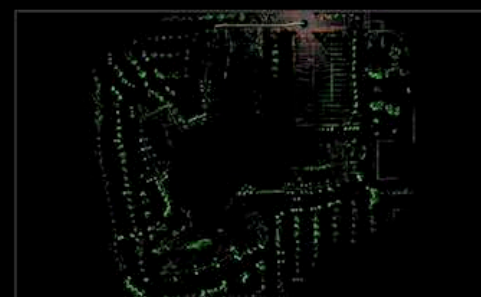
LIDAR Perception



Camera-based Mapping



Camera Localization to HD Map



LIDAR Localization to HD Map



Path Perception



Scene Perception

# TRADITIONAL HYPERSCALE CLUSTER

300 Dual-CPU Servers

\$3M

180 kW



# GPU-ACCELERATED HYPERSCALE CLUSTER

DGX-2 FOR DEEP LEARNING

1 DGX-2

10 kW

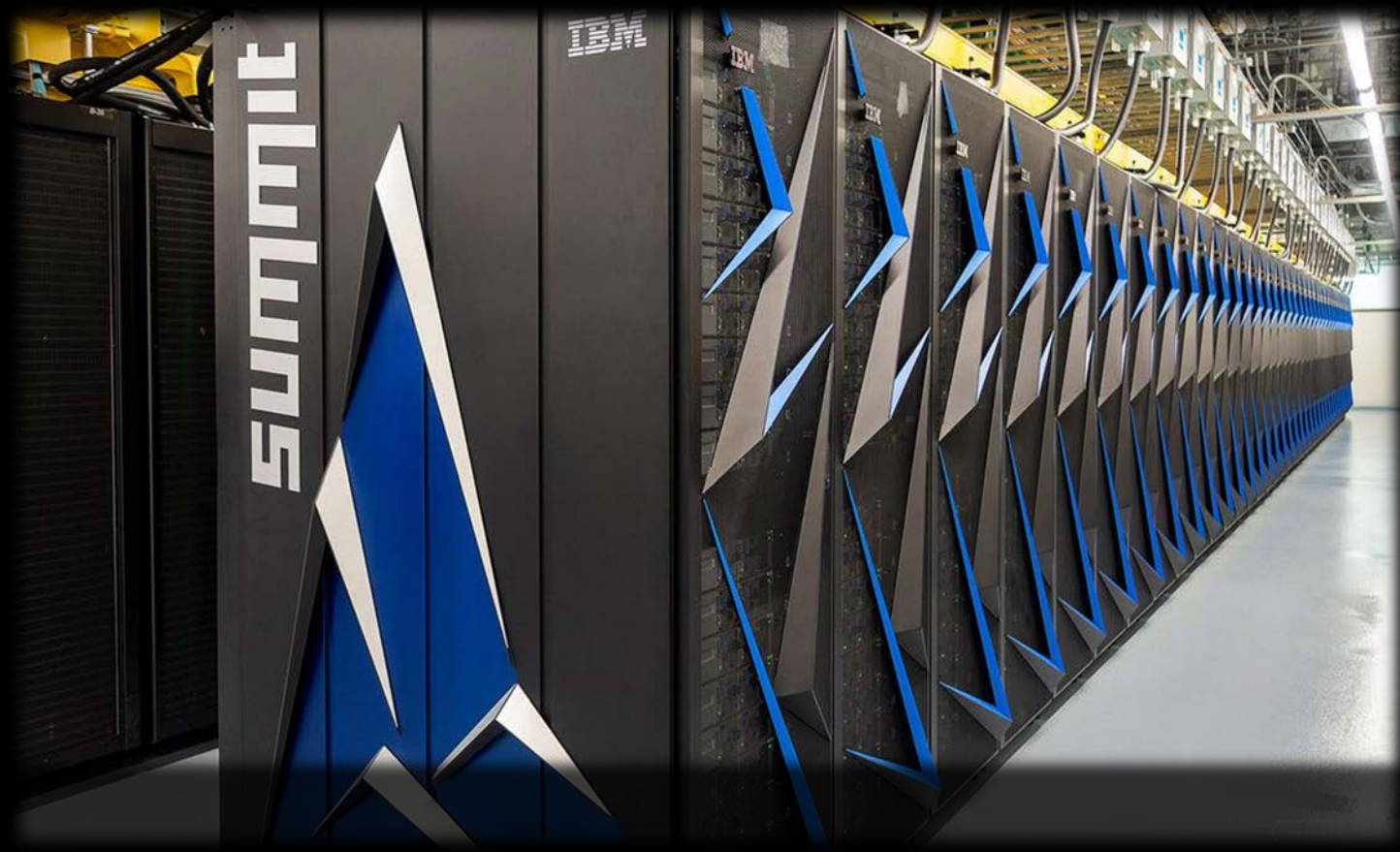
1/8 the Cost

1/60 the Space

1/18 the Power

# NVIDIA POWERS WORLD'S FASTEST SUPERCOMPUTER

Summit Becomes First System To Scale The 100 Petaflops Milestone

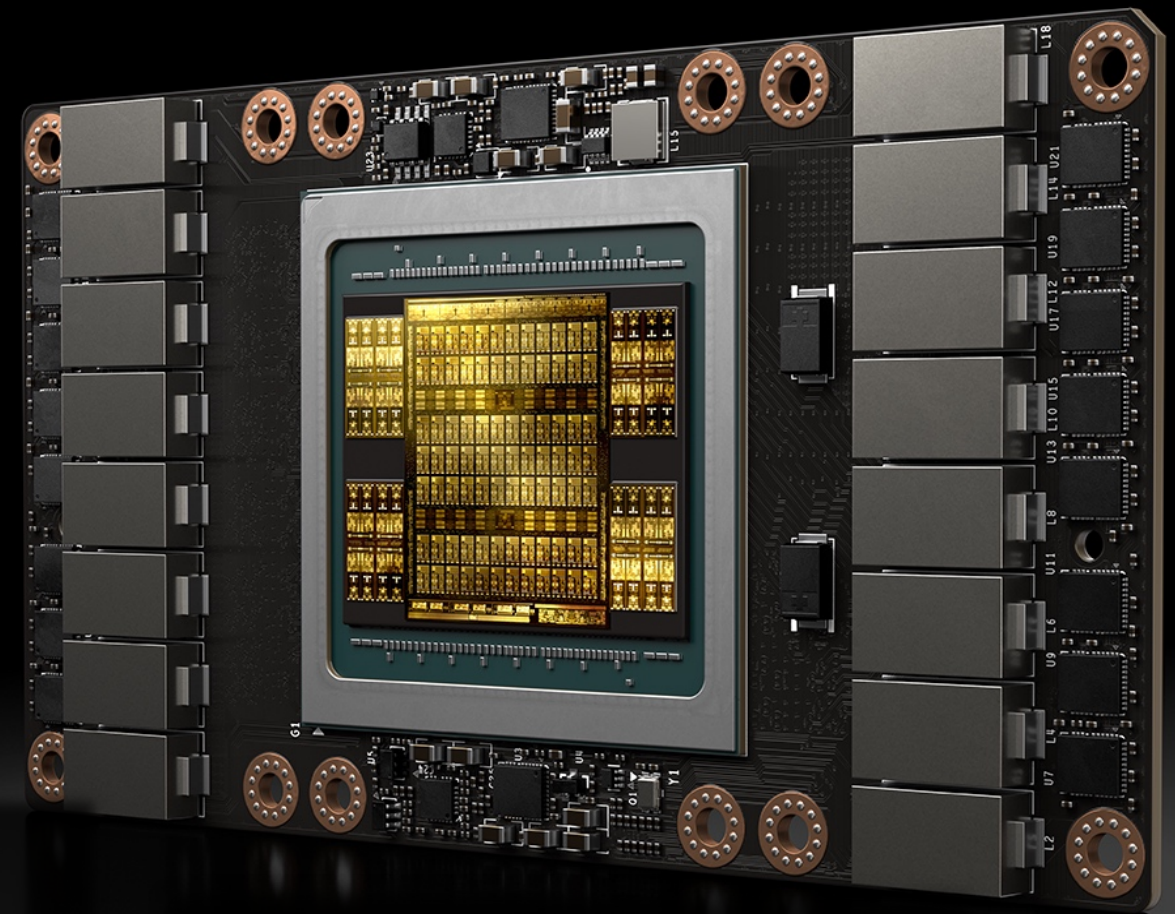


122 PF

HPC

3 EF

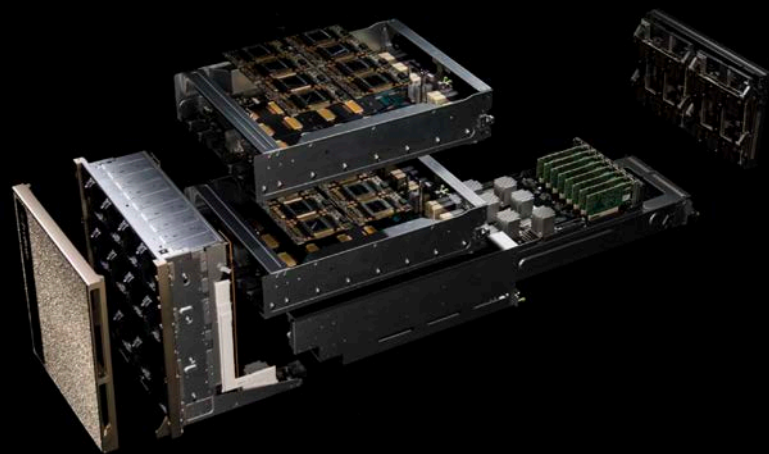
AI



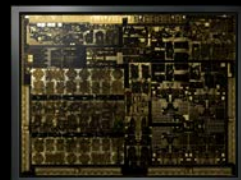
27,648

Volta Tensor Core GPUs

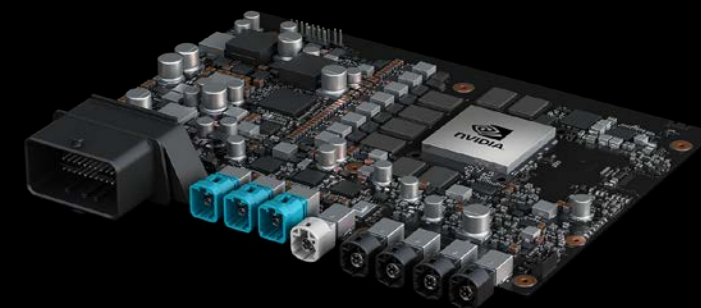
# UNIFIED AV ARCHITECTURE



AI DATACENTER PLATFORM



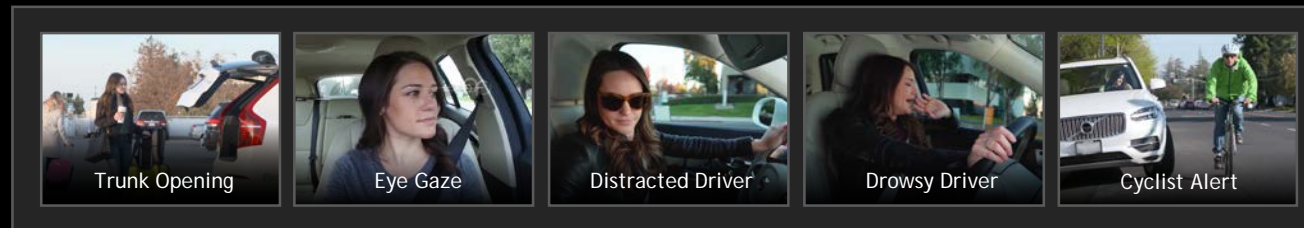
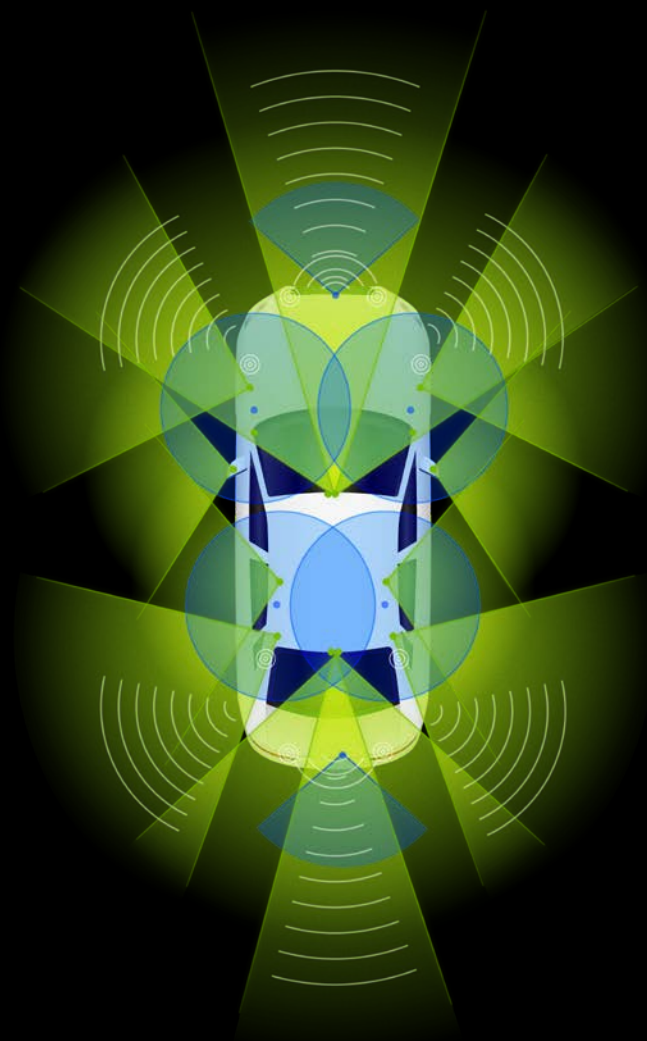
AI PROCESSOR ARCHITECTURE



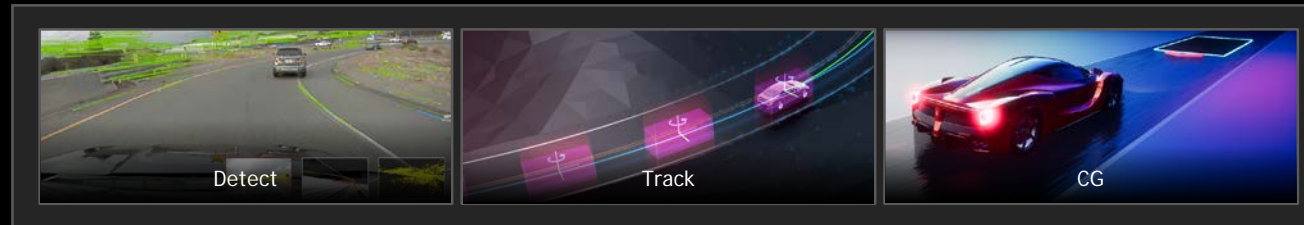
AI IN-VEHICLE PLATFORM

# FUTURE CAR IS SOFTWARE-DEFINED

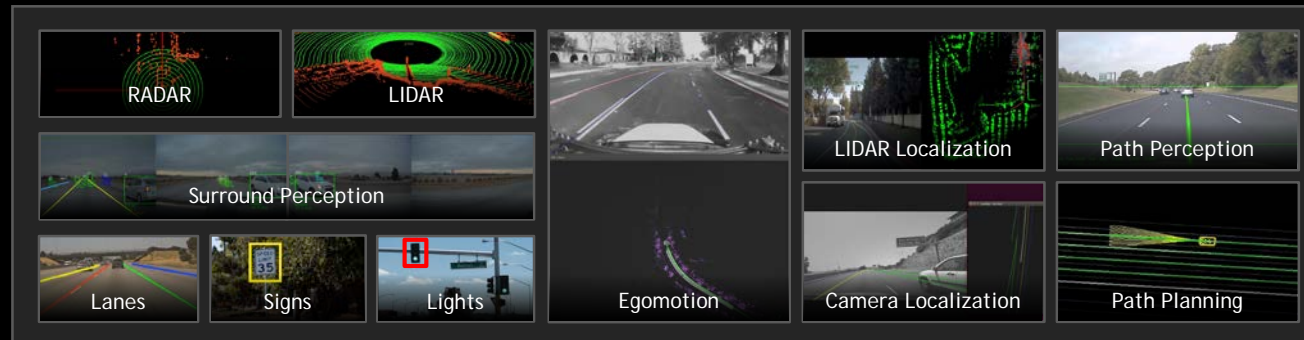
Powerful and Efficient AI, CV, AR, HPC | Rich Software Development Platform  
Functional Safety | Open Platform



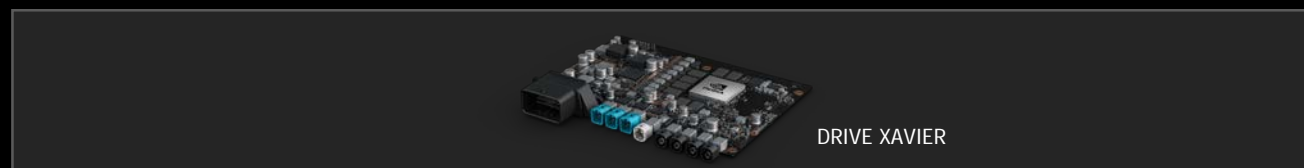
DRIVE IX



DRIVE AR

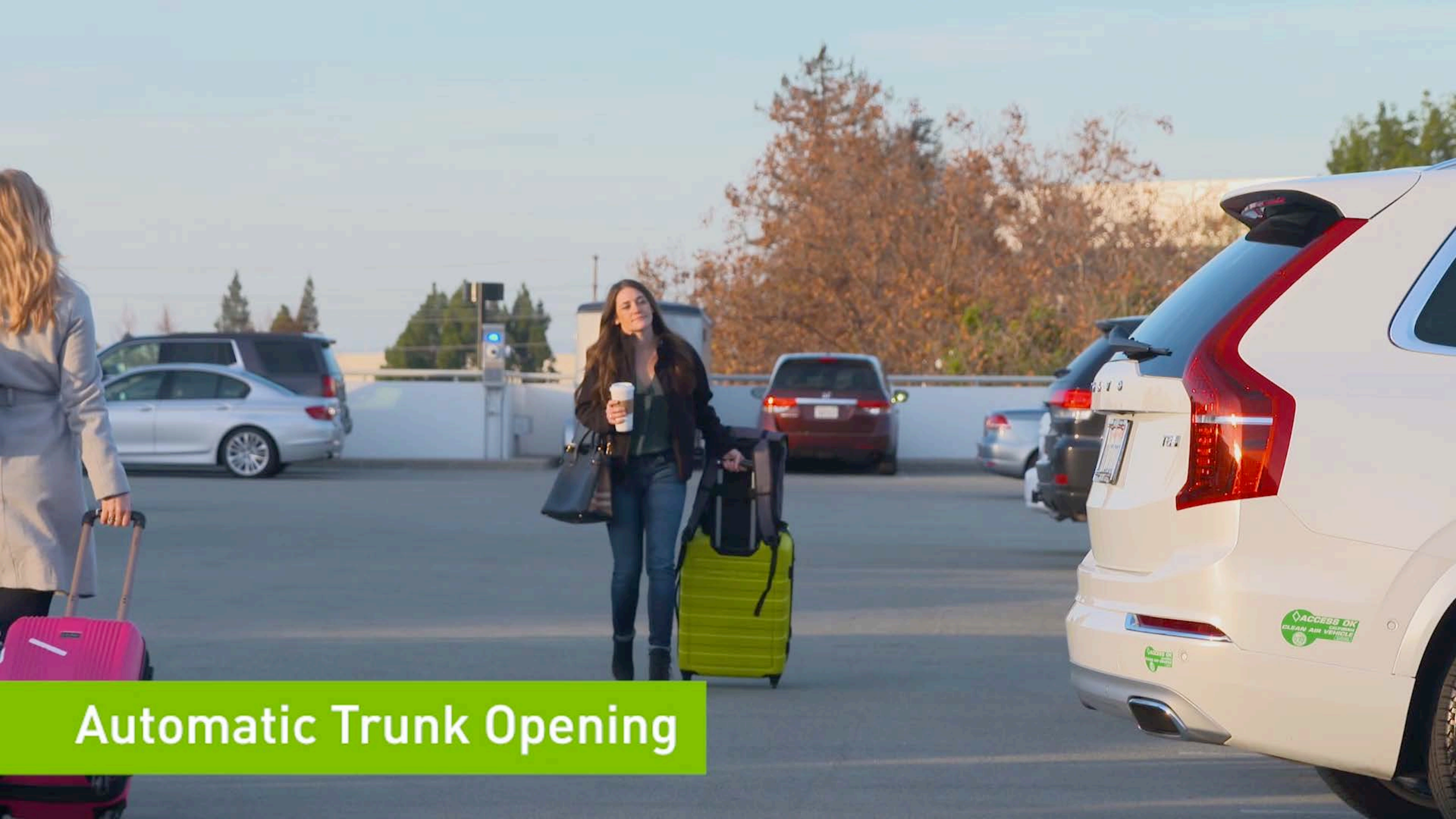


DRIVE AV



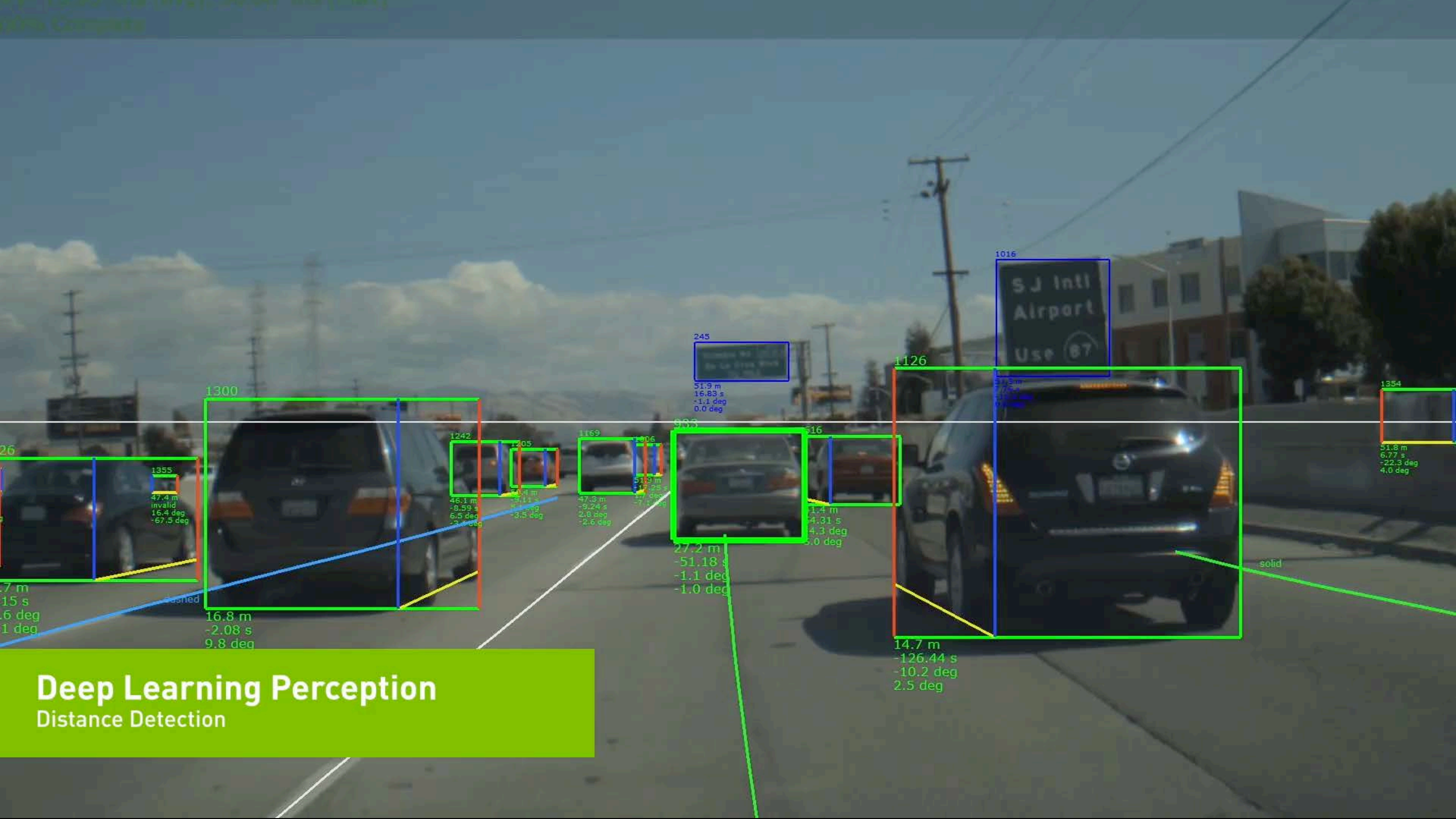
DRIVE OS

DRIVE XAVIER



# Automatic Trunk Opening





26  
1355  
47.4 m  
invalid  
16.4 deg  
-67.5 deg  
17.7 m  
15 s  
6 deg  
1 deg

1300  
1242  
1205  
1169  
1106  
983  
516  
1354  
51.8 m  
6.77 s  
-22.3 deg  
4.0 deg

16.8 m  
-2.08 s  
9.8 deg

245  
51.9 m  
16.83 s  
-1.1 deg  
0.0 deg

27.2 m  
-51.18 s  
-1.1 deg  
-1.0 deg

1016  
1126  
14.7 m  
-126.44 s  
-10.2 deg  
2.5 deg

solid

# Deep Learning Perception

## Distance Detection

# SDC SCALE TODAY AT NVIDIA

12-camera+Radar+Lidar RIG mounted on 30 cars	1,500 labelers	4,000 GPUs in cluster = 500 PFLOPs
1PB collected/week	20M objects labeled/mo	100 DRIVE Pegasus in cluster (Constellations)
15PB active training+test dataset	20 unique models 50 labeling tasks	1PB of in-rack object cache per 72 GPUs, 30PB provisioned

# SIMULATION

## THE PATH TO BILLIONS OF MILES

World drives trillions of miles each year.

A fleet of 20 test cars only covers 1 million miles / year.



# NVIDIA DRIVE™ CONSTELLATION

AUTONOMOUS VEHICLE VALIDATION SYSTEM

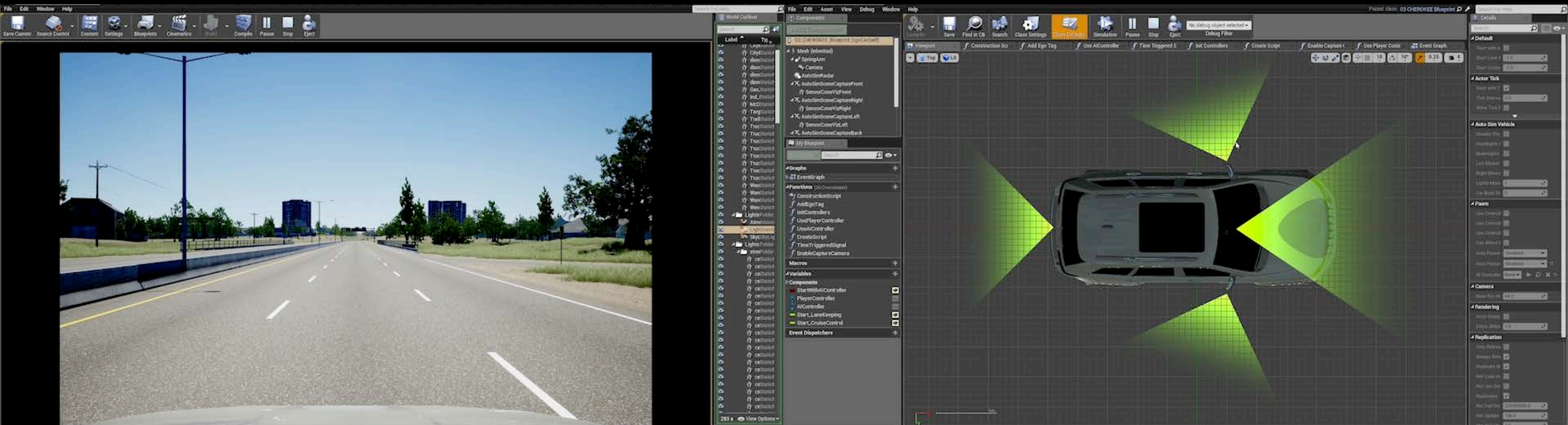


# NVIDIA DRIVE™ CONSTELLATION

AUTONOMOUS VEHICLE VALIDATION SYSTEM



# DRIVE™ SIM SENSOR CONFIGURATOR



# NVIDIA DRIVE™ SIM ENVIRONMENT



# HARDWARE IN-THE-LOOP

DRIVE SIM



DRIVE AV





# MULTI-SENSOR SIMULATION





**Euro NCAP Test  
Emergency Braking**





Euro NCAP Test  
Emergency Braking

# AV SYNTHETIC DATASETS

Virtual KITTI



# AI STYLE TRANSFER



# IMAGE-TO-IMAGE TRANSLATION



Input image

$$f(x)$$



Domain transferred image

# DAY TO NIGHT TRANSLATION



Input



Translated



# SNOWY TO SUMMERY TRANSLATION



Input



Translated



Input



Translated





# AI RESEARCH DRIVES INNOVATION



# 370+ PARTNERS DEVELOPING ON NVIDIA



CARS



TRUCKS



MOBILITY  
SERVICES



SUPPLIERS



MAPPING



SENSORS



STARTUPS



RESEARCH

