DEVELOPING & DEPLOYING AUTONOMOUS DRIVING APPLICATIONS
WITH THE NVIDIA DRIVE PX PLATFORM

Shri Sundaram, Product Manager, DRIVE PX Platform

NVIDIA
DRIVE PX: AV Development Platform

AV Developers: DRIVE PX as your tool

AV HW/SW Ecosystem: DRIVE PX as your platform to reach developers
NVIDIA DRIVE PX
Open AV Computing Platform for the Transportation Industry

Powerful and scalable AV computer

Deep Neural Network, Sensor Fusion and Computing

Extensive I/O to interface with wide range of sensors and vehicle networks

An open SW stack

Level 3 to Level 5; ASIL-D functional safety
DRIVE PX DRIVING AV AI

Launched CES 2015

Spike in AV AI engagements after we powered on discrete GPU

More than doubled in last 6 months

Plus >145 AV Startups on NVIDIA DRIVE

Source: NVIDIA statistics
AV DEVELOPMENT
Path from Idea to Production

IDEA ➞ DEVELOPMENT

Develop
- Perception
- Mapping/Localization
- Path Planning
- Combination/More...

PROTOTYPE

Test
- Feature development
- Validation

PRODUCTION

Deploy
- Safety hardening
- Performance tuning
- SW upgrades

OBJECTIVE

TOOL

PC

DRIVE Platform
Automotive Sensors
Production SW
OTA framework

Scalable compute with discrete GPUs
Ecosystem of sensors + other HW/SW peripherals
TensorRT, CUDA, Open Source Frameworks
DEVELOPMENT FLOW

Using DRIVE PX Platform

1. Data Acquisition to train DNN
2. Data Acquisition to Generate Map
3. Autonomous Application Development
4. Testing In-Vehicle or With Simulation
DATA ACQUISITION
Rapidly Growing Ecosystem of Supported Sensors & Storage Solutions

Sensor fusion interfaces:
GMSL Camera, CAN, GbE, BroadR-Reach, FlexRay, LIN, GPIO

Displays interfaces
HDMI, FPDLink III and GMSL

Storage Interfaces
10GbE, USB3 (also HDMI)
VISION CAMERAS - SEKONIX & LEOPARD

Sekonix

- Camera Module based on latest AR0231 Automotive sensor from On Semi
- IP69K waterproof packaging
- Ultra high resolution lens

Leopard

- Wide range of sensors from OnSemi, SONY and Omnivision
- Proof of concept & quick turn
THERMAL CAMERAS
FLIR Thermal Sensor – Automotive Development Kit (ADK)

Thermal sensors create images from heat, not light, so they can detect pedestrians and oncoming vehicles regardless of lighting conditions.

Start collecting thermal data in minutes
Easy set-up, operation, and integration
Most importantly available on NVIDIA DRIVE™ PX 2 support available.
Under development
STORAGE SOLUTIONS
from Quantum and AutonomouStuff

- QUICKER — MORE AGILE — DEVELOPMENT CYCLES
- FASTER ACCESS TO NEW TEST DATA
- SHARED STORAGE, HPC PERFORMANCE, NO SILOS
- 10% THE COST OF ALTERNATIVE SOLUTIONS
- RETAIN MORE DATA LONGER
DRIVE PX + SENSORS CONFIGURED TO GO

With Ford Fusion + DRIVE PX + cameras, LIDAR, radar, navigation sensors and storage options

Photo courtesy of AutonomouStuff
DATA ACQUISITION
Tools to acquire, time stamp, sync and store data

1. Route setting
2. Configuration switching
3. Storage info
4. Camera preview
5. Start Recording control button
6. Settings button
7. GPS info
8. Sensor Status

Set Route ID; File Config (RAW, Lossless RAW, Compressed), start/stop recording!
Get useful information about storage left, camera preview, sensor status
DEVELOPMENT FLOW
Using DRIVE PX Platform

1. Data Acquisition to train DNN
2. Data Acquisition to Generate Map
3. Autonomous Application Development
4. Testing In-Vehicle or With Simulation
PUTTING IT ALL TOGETHER
AV App Development

DEVELOP

- Trained Neural Network Model (DNN)
- Hi Def Maps
- Data Acquisition & Sensor Fusion
- Algorithms, Applications

BENCHMARK / DEPLOY

LINUX PC

DRIVE PX 2

Cross-Compile
Feedback & Iterate
EMBEDDED SOFTWARE DEVELOPMENT WORKFLOW

SOFTWARE DEVELOPMENT

TOOLCHAIN SETUP
CROSS-COMPILATION
PORTING

REMOTE DEBUGGING

REMOTE PROFILING

RUN

DEBUG
CPU/GPU

Cuda-gdb
Cuda-memcheck

PROFILE
SYSTEM/CPU/GPU/IO/...

PerfWorks
CUPTI

nvprof

SHIP IT!
DRIVE SOFTWARE STACK

DRIVE PX

DriveWorks Tools

Sensors & Maps

Cameras

NVMEDIA

CUDA libraries & engines (including CuDNN/TensorRT)

DRIVE OS, CUDA

DNNs

DriveWorks Algorithm Modules

Autonomous Driving Applications

DriveWorks Algorithm Modules

CUDA libraries & engines (including CuDNN/TensorRT)

DRIVE OS, CUDA

DNNs
TEST / DRIVE
With PX on Wheels Research Vehicles
DRIVE PLATFORM TODAY FOR LEVEL 3/4

DRIVE Platform - Open AI Autonomous Vehicle platform

DRIVE PX 2 → DRIVE PX Xavier
One Architecture, Increased Performance per Watt
DRIVE PLATFORM
For Production

DRIVE PX
DRIVE OS
DRIVEWORKS SDK
DRIVE AV

Level 3 to Level 5 | ASIL-D Functional Safety
Placeholder to amplify whatever gets revealed in JHH GTC Keynote
<table>
<thead>
<tr>
<th>Session Description</th>
<th>TUE (10/10)</th>
<th>WED (10/11)</th>
<th>THU (10/12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION AND INTEGRATION WITH DRIVEWORKS ON DRIVE PX2</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>By Aaraadhya Narra &amp; Alessandro Ferrari (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUDA PROGRAMMING ON DRIVE PX2</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>By Siva Rama &amp; Chethan Ningaraju</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGLSTREAMS: INTEROPERABILITY FOR CAMERA, CUDA AND OPENGL</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Yogesh Kini, Anshuman et. al (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEPLOYMENT OF SEMANTIC SEGMENTATION NETWORK USING TENSORRT</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Joohoon Lee &amp; Chethan Ningaraju</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# OTHER RELATED SESSIONS

**By NVIDIA partners**

<table>
<thead>
<tr>
<th>Session Title</th>
<th>TUE (10/10)</th>
<th>WED (10/11)</th>
<th>THU (10/12)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AI DRIVEN ENVIRONMENT MODELING FOR AUTONOMOUS DRIVING ON NVIDIA DRIVE PX 2</strong></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Alexey Abromov, Continental (14c)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ARCCORE'S PLATFORM SOLUTIONS FOR SELF-DRIVING CARS</strong></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Eric Envall &amp; Hakan Berglund (Arccore) (14c)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OPEN FUSION PLATFORM FOR AUTOMATED DRIVING CARS BASED ON NVIDIA DPX2</strong></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Paulin Fouopi and Mohsen Sefati</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DESIGNING A SOFTWARE FRAMEWORK FOR AUTOMATED DRIVING</strong></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Sebastian Ohl, Elektrobit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMBINING AI, RGB, AND 3D FOR SELF-DRIVING COGNITION SYSTEMS</strong></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Yaron Tanne/Doron Elinav, Vayavision</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VISUAL PERCEPTION FOR AUTONOMOUS DRIVING ON THE NVIDIA DRIVEPX2 AND USING SYNTHIA</strong></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By Juan Moure/Antonio Espinosa, Barcelona</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OTHER RESOURCES

TOOLS
Developer Zone (developer.nvidia.com/DRIVE)
Developer Forums (devtalk.nvidia.com)

SCHOOLS
Deep Learning Institute - Autonomous Driving
Udacity Nanodegree

OTHER PRESENTATIONS
AUTOSAR STACK FROM ELEKTROBIT
Included & Preinstalled with DRIVE PX 2
AUTOSAR REFERENCE STACK FROM ARCCORE

Automotive Software Platform for DRIVE PX2

Note! In the DrivePX2 Evaluation kit only one of the 3 Cores is utilized in Aurix
AUTOSAR REFERENCE STACK FROM ARCCORE
Automotive Software Platform for DRIVE PX2

Embedded ECUs
- Classic AUTOSAR platform
- Multicore extension to classic AUTOSAR
- Safety up to ASIL-D
- Support for DrivePX2 3LSS Safety SW Architecture (NVIDIA)

High performance embedded ECUs (Linux/QNX)
- Adaptive AUTOSAR
- Virtual AUTOSAR ECUs

Ethernet communication
- SOME/IP - Service Discovery Ethernet protocol
- gPTP TimeSynchronization

Development Tools
- AUTOSAR Authoring and BSW configuration
- System Replay for Virtual Verification and Function Development
- Realtime Analysis Tool
- Logging
- 3D/360 Sensor analysis viewer
V2X - COHDA WIRELESS

NVIDIA PX2
Cohda V2X
Stack/Apps
802.11p remote
driver

Cohda MK5
802.11p

Cohda MK5
V2X
Stack
Apps

Ethernet