INSIDE NVIDIA'S AI INFRASTRUCTURE FOR SELF-DRIVING CARS

CLEMENT FARABET | NVIDIA | GTC Europe
NVIDIA DRIVE: SOFTWARE-DEFINED CAR

Powerful and Efficient AI, CV, AR, HPC | Rich Software Development Platform
Functional Safety | Open Platform | 370+ partners developing on DRIVE

DRIVE IX
- Trunk Opening
- Eye Gaze
- Distracted Driver
- Drowsy Driver
- Cyclist Alert

DRIVE AR
- Detect
- Track
- CG

DRIVE AV
- RADAR
- LIDAR
- Surround Perception
- LIDAR Localization
- Path Perception
- Camera Localization
- Path Planning

DRIVE OS
- DRIVE AGX XAVIER
- DRIVE AGX PEGASUS

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BUILDING AI FOR SDC IS HARD

Every neural net in our DRIVE Software stack needs to handle 1000s of conditions and geolocations.
WHAT TESTING SCALE ARE WE TALKING ABOUT?

We’re on our way to 100s PB of **real** test data = **millions of real miles**
+ 1,000s DRIVE Constellation nodes for **offline testing alone** & **billions of simulated miles**

– Target robustness per model (miles)
-- Test dataset size required (miles)
– NVIDIA’s ongoing data collection (miles)

* DRIVE PEGASUS Nodes
### SDC Scale Today at NVIDIA

<table>
<thead>
<tr>
<th>12-camera+Radar+LiDar RIG mounted on 30 cars</th>
<th>1,500 labelers</th>
<th>4,000 GPUs in cluster = 500 PFLOPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1PB collected/week</td>
<td>20M objects labeled/mo</td>
<td>100 DRIVE Pegasus in cluster (Constellations)</td>
</tr>
<tr>
<td>15PB active training+test dataset</td>
<td>20 unique models 50 labeling tasks</td>
<td>1PB of in-rack object cache per 72 GPUs, 30PB provisioned</td>
</tr>
</tbody>
</table>
Developing AI for industrial applications is bottlenecked by our ability to “develop” the right datasets, run the right experiments, instrument, and ultimately automate.

If we solve these problems, then adding more GPUs can mean more rapid progress.
DATASET LIFECYCLE MANAGEMENT

Probably our most challenging problem

Build and compose PB datasets

DL App dataset consumption

SSD Upload Store

DriveWorks Parser

Data Warehouse

Cloud Storage

Meta-Storage

Query Engines

Presto

Spark

Hive

Clients

Data+DNN Metrics

Export Service

Web-based SQL UI

Notebooks

HumanLoop

Pipelines

Load/Decode

Batching

Preprocessing

Augmentation

Ground-truth rasterization

...
ML PIPELINE AUTOMATION

Hybrid cluster deployment
100% Kubernetes-based
Multi-node training via MPI over k8s
20+ microservices
Underlying k8s arch shared with NGC

1. Submit workflow

2. Handle dataset preparation and mounting

3. Render and launch workflows

4. Launch jobs

5. Listen for updates on workflows, jobs and mpi-jobs

Compute Cluster (DGX @ NVIDIA)

Service cluster (Cloud)

Dataset Service

Access Management Service

Postgres / ElasticSearch

Experiment Service
MAGLEV MODEL ANALYTICS & INSIGHTS

Rapidly retrieve experiment results
Analyze them in a notebook
Find best models

Visualize the impact of different parameters on KPIs

```python
In [13]:
df = get_summary_dataframe(model_versions, param_sets, kpis_to_use, params, prune_ratios, average_folds=False)
pairplot(df, params, kpis_to_use)
```
MAGLEV: AUTOMATION & TRACEABILITY

Empower Prod engineers to run or schedule complete workflows & version everything

Production Engineer

Optimize app perf

Deploy prod applications

4000-GPU Cluster

Run/Debug Applications

ML Developer

Develop Applications

Analyse Experiments/results

Code Repository

App #1

Git+CI based Workflow Launcher

App #2

Manual Workflow Launcher

App #N

Traced Asset Repository

Models

Datasets

Metrics

Code Version

NVIDIA DRIVE Car

Deploy applications

Publish

Develop Applications

Analyze Experiments/results

Optimize app perf

Empower Prod engineers to run or schedule complete workflows & version everything
HYBRID CLUSTER

"Collect ⇒ Select ⇒ Label ⇒ Train ⇒ Test" as programmatic workflows

Cloud Kubernetes over 4000 GPU Cluster (= 480 PFLOPs)

Data Lake
15PB Today

Ingest 1PB per week

Labeling UI
1,500 Labelers

Labeling UI

Metrics & Logs

Labeled Datasets
20M objects labeled per month

Data selection
1PB per week

Selected Datasets

Data selection

Job #1

Data selection

Job #N

Training Job #1

Training Job #N

Training Job #1

Training Job #2

Training Job #N

Metrics & Logs

Trained Models

20 models actively developed

Labeling UI

ML/Metrics UI

Large AI Dev team

1,500 Labelers

Ingest

Run Multi-Step Workflow
(workflow = sequence of map jobs)

1PB per week

Ingest

Cloud

15PB Today

Ingest

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Ingest

Data Lake

selected Datasets

Labeled Datasets

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15PB T
Each rack:
9 DGX-1 = 72 TESLA V100 GPUs = 9 PFLOPs
12 CPU nodes for services & data management
1.2PB per rack of cache can front object storage

1PB per week

15PB Today

MAGLEV DATA CENTER ARCHITECTURE

Cloud Provider
Object Storage

On Premise
Object Storage

35kW Rack
CPU Node
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MagLev Platform

Kubernetes

nvidia
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