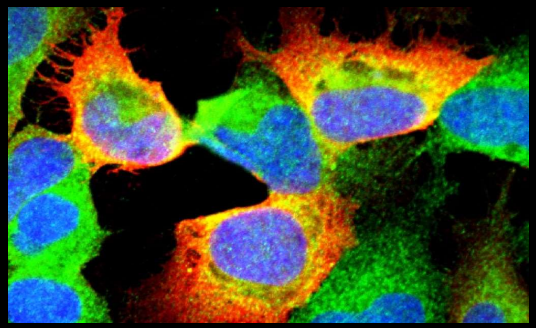
Opportunities in real-time 3D autonomous driving simulations

Jon Hogins, Sr. Software Engineer

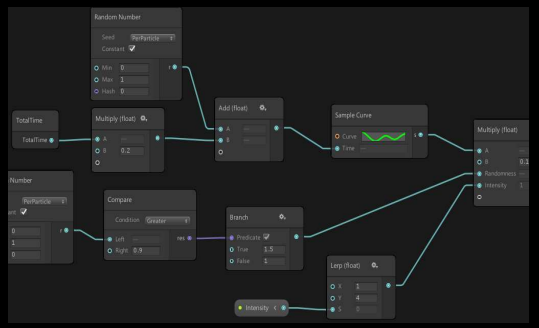
unity

Background



Computer vision algorithms for segmentation, identificaiton, and tracking

Real-time rendering using GPU compute



Programming language & creative tool design

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Game engines will be critical in solving the AV problem

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Autonomous Vehicle Perception Problem

- AV perception is driven by **Machine Learning**
- ML development is extremely **data heavy**
- Collecting data for ML is **expensive**
- Annotating data is both **expensive and error prone**
- **Real-world** data can only prepare for what **has already happened**

Explosion of Real-Time 3D

Real-time 3D engines are transforming our world.

- Optimized performance
- Flexible rendering
  - Physically-based rendering
  - Post-processing
  - Real-time ray tracing
- Mature content workflows

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Can We Use Synthetic Data?

Research says yes

- Barcelona, Stanford, … have published papers validating the approach
- Techniques like domain randomization proving useful
- Area of active research – flexibility is key

Unity as a Simulation Platform for Autonomous Vehicles

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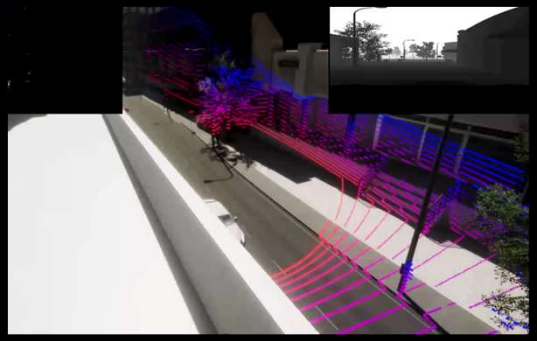
Unity is Growing as a Simulation Platform

- Rendering Pipeline Options for Realism and Performance
- Other Enhanced Rendering Capabilities
- New Data-oriented Tech Stack
- Asset Store to Bootstrap Content
- New Editor and Workflow Capabilities
- Pluggable Physics
- TensorFlow Integration for Agent Training (ML Agents)

Rendering Pipeline Options

Render for your specific training application



Scriptable Render Pipeline

Highly customizable rendering technology allows you to tailor rendering to hardware and implement sensor-relevant rendering details with granular control.

Universal Render Pipeline

Most processor efficient rendering option with improvements in effect quality. Useful for lower resolution applications. Easy to customize with C#.

High Definition Render Pipeline

High fidelity visuals for the performance critical applications (reflections, glare). Professional processing tools. Simulate physical cameras precisely.

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Extra Rendering Capabilities

Ensure lighting is optimal for simulation realism

Real-time Ray Tracing

Moves graphics significantly closer to realism, opening the doors to global rendering effects once thought impossible in real-time.

GPU Progressive Light Mapper

Allows incredible iteration speeds for lighting and level design by providing interactive updates and continuous feedback.

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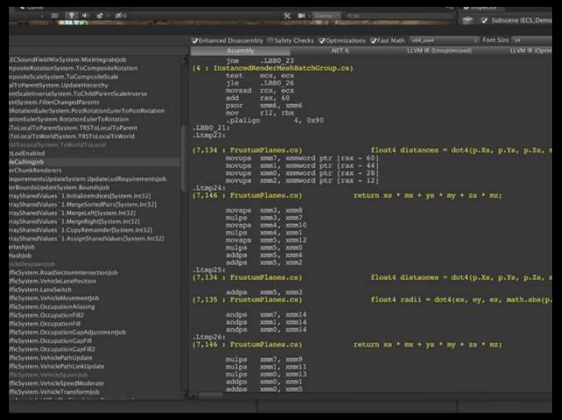
Data-oriented Tech Stack (DOTS)

Scale your simulations to match the real world



Entity Component System

Framework for organizing data for scalable compute on modern hardware.

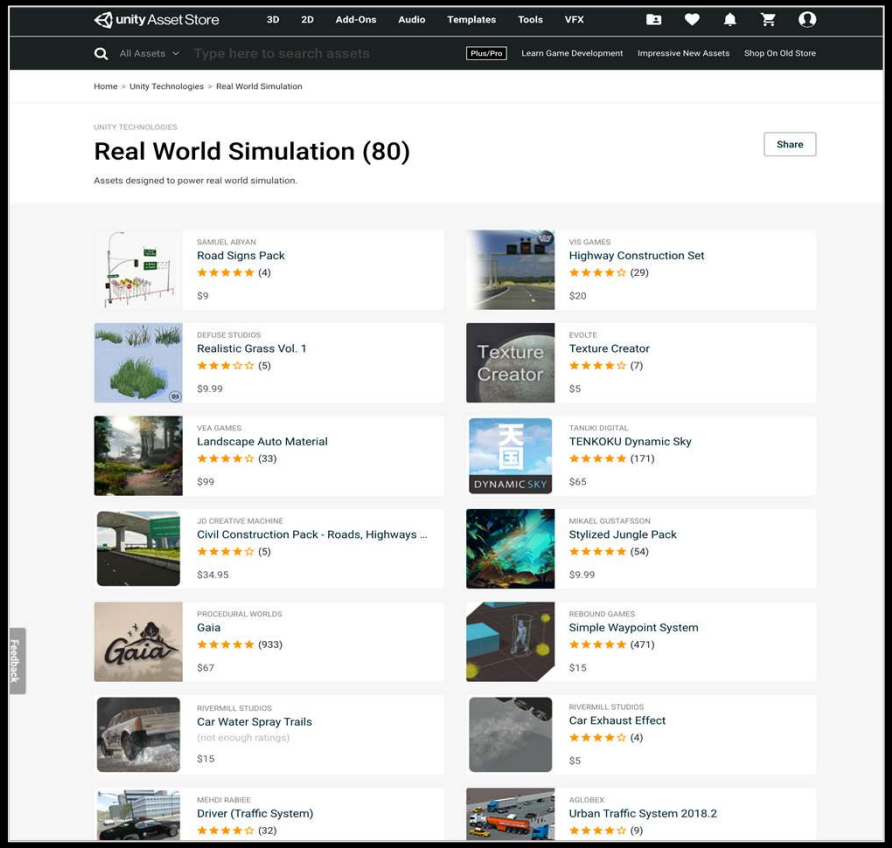
C# Job System

Take full advantage of multicore processors without all the programming headache.

Burst Compiler

High performance C# compiler for optimized simulation.

Asset Store



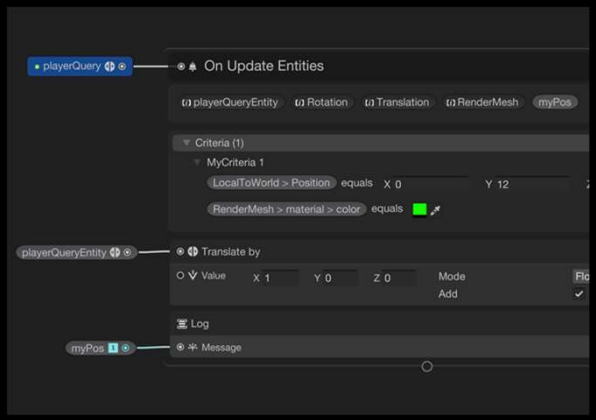
https://assetstore.unity.com/lists/real-world-simulation-54066

EasyRoads3D HD Pack (Andasoft)

Enviro - Sky and Weather (Hendrik Haupt)

New Editor and Workflow Capabilities

Create more complete environments more quickly



Timeline

Orchestrate scenes and choreograph sequenced events. Fully extensible and automatable.

Environment 2.0

Scalable terrain authoring using a node-based approach to design procedural rules.

DOTS Visual Scripting

Bridge the gap between content creators and engineers through visual programming.

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Pluggable Physics

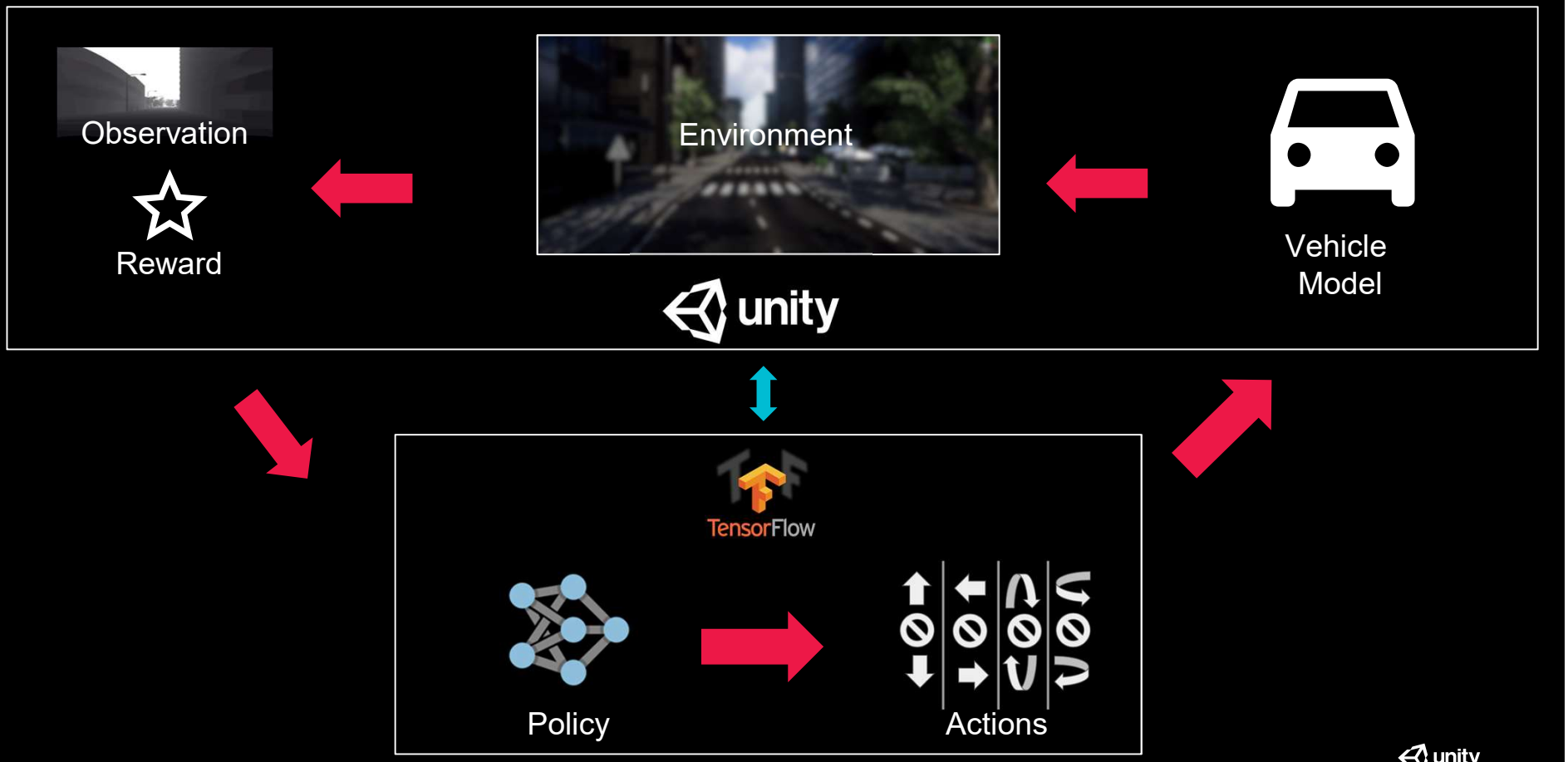
DOTS Physics

Next generation Unity physics with customizable C# package. Scales to many cores

Havoc Physics

Powered by the industry leading Havok physics engine. Higher performance with lots of dynamic rigid bodies due to caching.

Connect to TensorFlow for Agent Training



A Vision for AV Simulation

The Autonomous Vehicle Industry Has Proactively Adopted Unity

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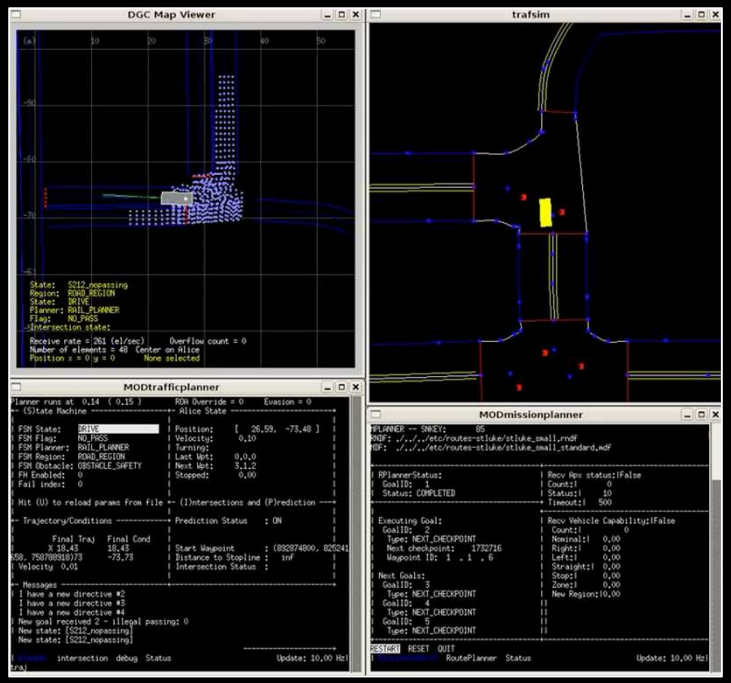
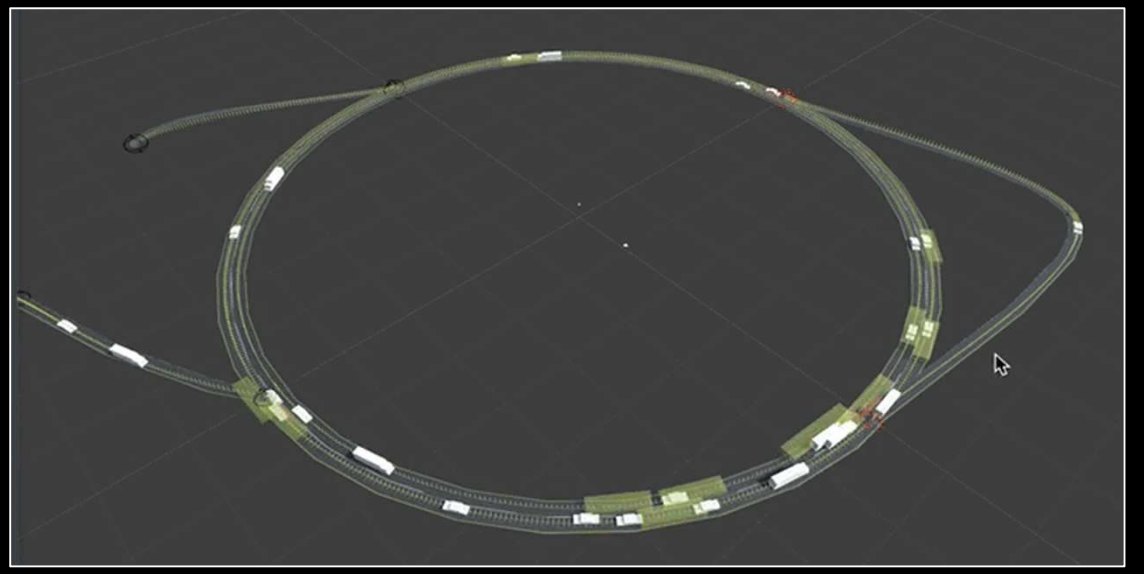
Camera Customizations for Perception

CVEDIA

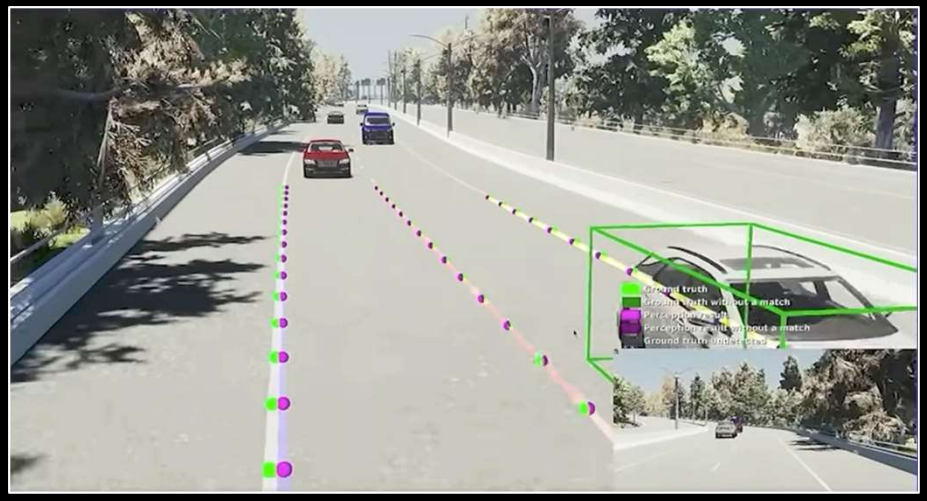
Non-visual Planning Simulators

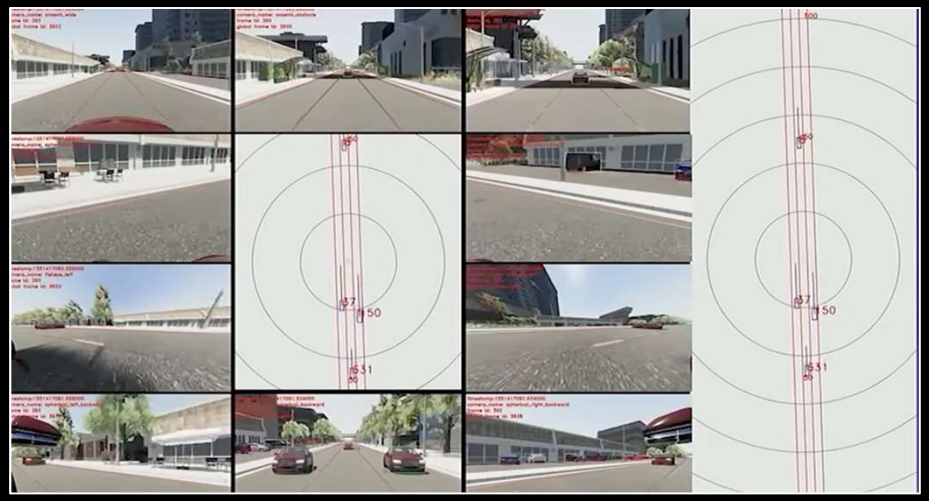




THRE'E

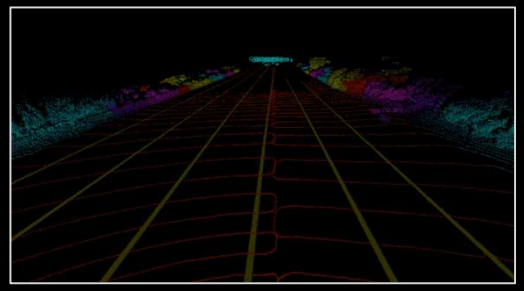
Showcase: Baidu’s Apollo





Baidu 百度 | apollo

A Snapshot of Our Ecosystem



Baidu 百度

metamoto

LUMINAR

VOLVO

TOYOTA RESEARCH INSTITUTE

cognata

THRE'E

WRLD

CVEDIA

VECTORZERO

itk ENGINEERING

ECHODYNE

UDACITY

Microsoft

mapbox

NewSpace RESEARCH & TECHNOLOGIES

UAB Universitat Autònoma de Barcelona

CVC Centre de Visió per Computador

INDAGO

Three Reusable Sample Environments

Artificial Scenes included:

- Urban
- Suburban
- Highway

INDAGO

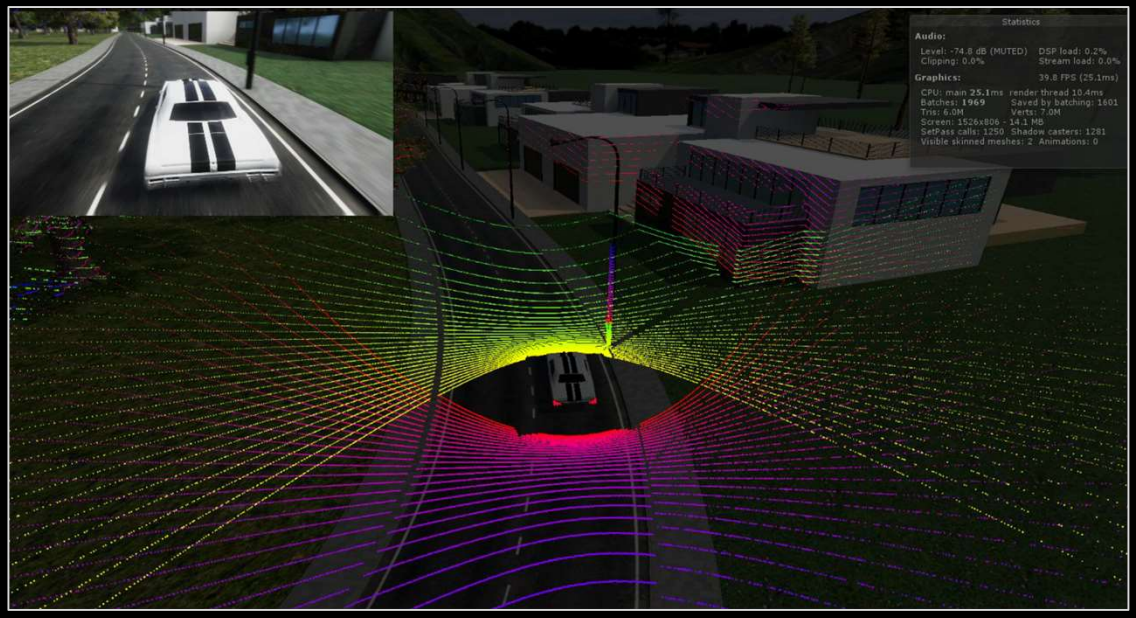
Some Demo Implementations of Sensors

SynCity Lite

Sensor Models included:

- RGB-D Camera
- LiDAR
- Radar
- IMU
- GPS

CVEDIA



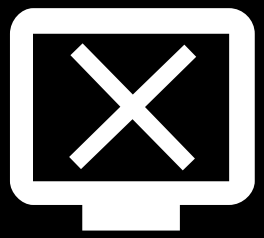
Trends and Challenges Ahead of Us

We still need to scale data ***massively.***

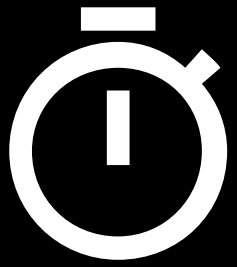
11 Billion Miles*	=	100 AVs	driving	24hr/ 365day/ 25mph	for	500 years
Needed to drive better than humans with confidence		Fleet of 100 autonomous vehicles		Running for 24 hours a day for 365 days a year at 25mph		Testing for 500 years consecutively

* Estimation by RAND Corporation in 'Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability?' (2016)

Unity is positioned to scale on the Cloud



Headless
Execution



Optimized
Runtime

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Research Trend Towards E2E Learning

End-to-End Learning of Driving Models from Large-Scale Video Datasets

Huazhe Xu, Yang Gao, +1 author Trevor Darrell ·
Published in IEEE Conference on Computer Vision and Pattern... 2016 · DOI: 10.1109/CVPR.2017.376

End-to-end Multi-Modal Multi-Task Vehicle Control for Self-Driving Cars with Visual Perceptions

Zhengyuan Yang, Yixuan Zhang, +2 authors Jiebo Luo ·
Published in 24th International Conference on Pattern... 2018 · DOI: 10.1109/icpr.2018.8546189

Great Need, Few Established Practies

- Industry knows that physical testing does not scale
- Who will implement the sensor models?
- Who will create the environments?

- Unity will walk this road with you
  - ASAM Member
  - Applied research
  - Support, services, and partnerships

Thank you.

#unity3d