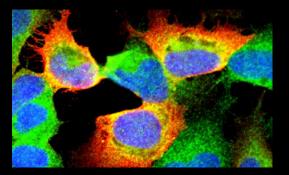
# Opportunities in real-time 3D autonomous driving simulations

Jon Hogins, Sr. Software Engineer

🚓 unity

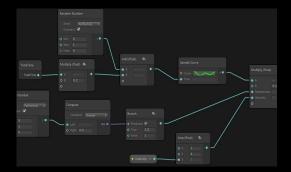
## Background



Computer vision algorithms for segmentation, identificaiton, and tracking



Real-time rendering using GPU compute



Programming language & creative tool design

# 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



## **Can We Use Synthetic Data?**

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#### Research says yes

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

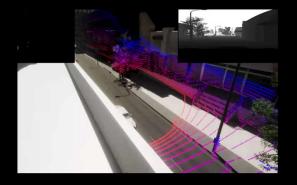
## Unity as a Simulation Platform for Autonomous Vehicles

## **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**

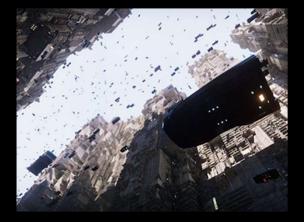
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Allows incredible iteration speeds for lighting and level design by providing interactive updates and continuous feedback.

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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

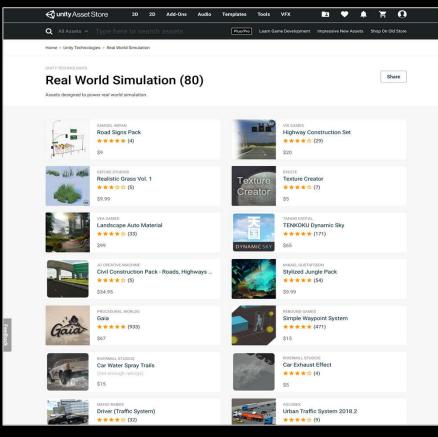
Take full advantage of multicore processors without all the programming headache.

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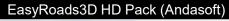
#### **Burst Compiler**

High performance C# compiler for optimized simulation.

#### **Asset Store**



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





Enviro - Sky and Weather (Hendrik Haupt)



## **New Editor and Workflow Capabilities**

Create more complete environments more quickly

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#### 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.

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#### **DOTS Visual Scripting**

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

## **Pluggable Physics**

#### **DOTS Physics**

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

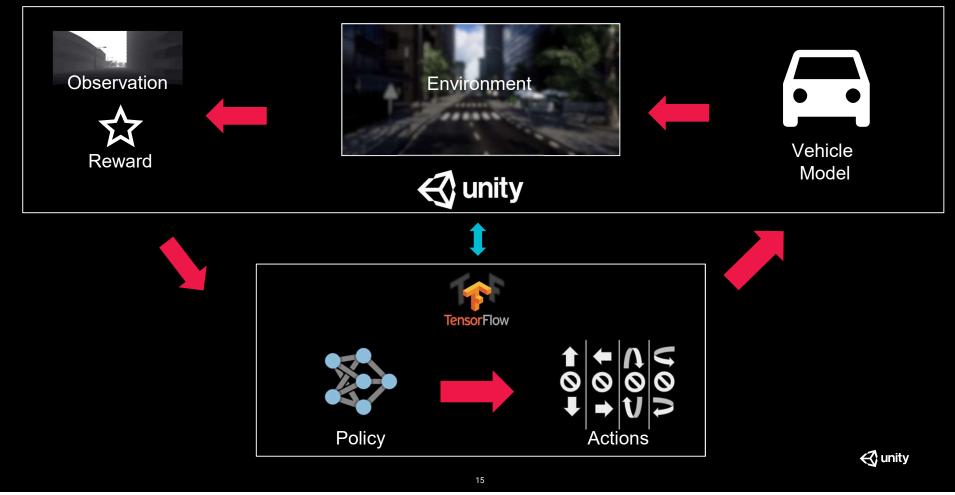


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#### **Havoc Physics**

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**

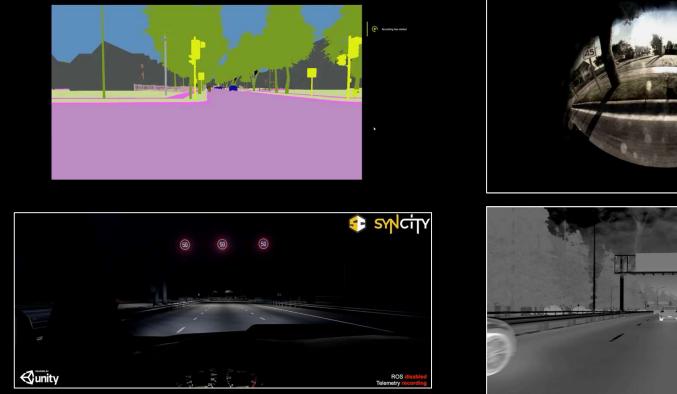


## **A Vision for AV Simulation**



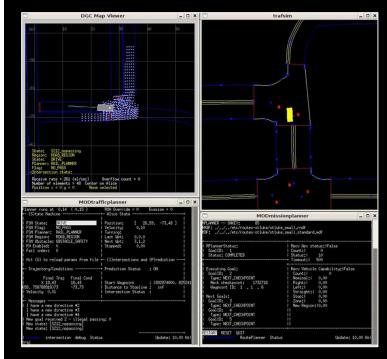
# The Autonomous Vehicle Industry Has Proactively Adopted Unity

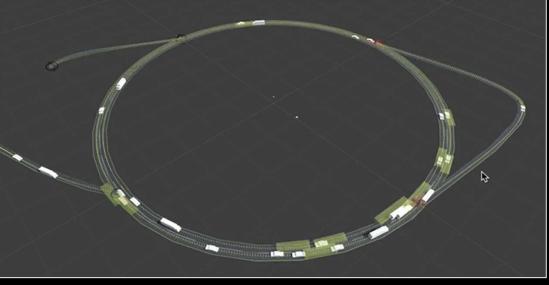
## **Camera Customizations for Perception**





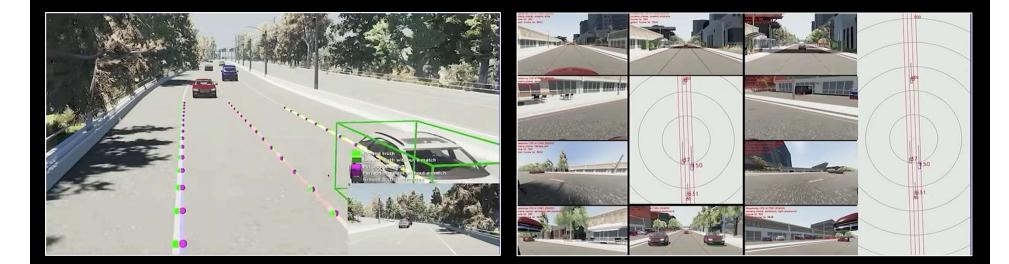
## **Non-visual Planning Simulators**







## Showcase: Baidu's Apollo



### **A Snapshot of Our Ecosystem**



## Three Reusable Sample Environments





#### **Artificial Scenes included:**

- o Urban
- $\circ$  Suburban
- $\circ$  Highway

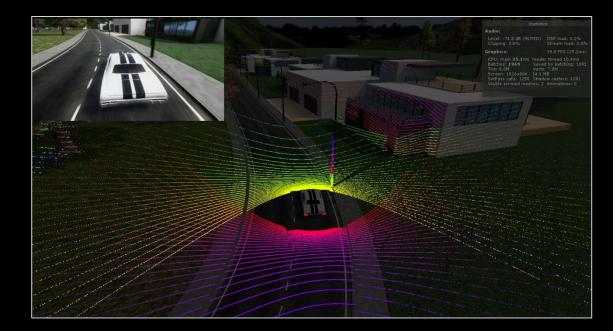




## Some Demo Implementations of Sensors

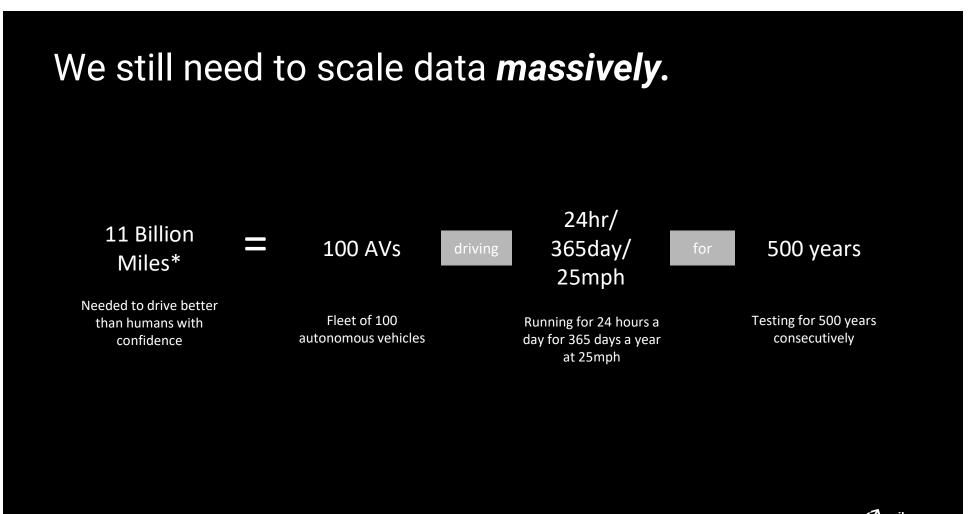
## **SynCity Lite**

Sensor Models included: RGB-D Camera LiDAR Radar IMU GPS



## Trends and Challenges Ahead of Us

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

## Unity is positioned to scale on the Cloud



Headless Execution



Optimized Runtime

### **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

