### Enabling Next-Gen Effects through NVIDIA GameWorks New Features

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### **Overview**

- GPU Rigid Bodies (GRB)
- FleX
- Flow
- WaveWorks

# **UE4-GRB Demo**



# **GPU Rigid Bodies in PhysX 3.4**

- A new feature introduced in PhysX 3.4
- Implemented in CUDA
- Supports Windows and Linux with NVIDIA Kepler (GTX 6 series) GPU or later
- Same API and semantics as CPU PhysX rigid bodies
- Supports most PhysX rigid body features except articulations

# GPU Rigid Bodies in PhysX 3.4 cont.

- Hybrid CPU/GPU rigid body simulation
- Execute the following rigid body pipeline stages on GPU
  - Broad phase
  - Narrow phase
  - Solver
  - State management
  - Bounds computation
- Execute the following stages on the CPU
  - Island management
  - Shape filtering
  - CCD
  - Triggers
  - User callbacks

# **Performance Results**

### Test Platform

- Windows 10 64-bit
- I7-5930k
- 32GB RAM
- GTX 1080



# 13,824 Convex Objects



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# Hallway (16,000)



# Arena Demo (15, 000)



### Kapla Tower 20,000 convexes



# 700 Ragdolls



### **Overview**

- GPU Rigid Bodies (GRB)
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## FleX In Funhouse



FleX









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### **Motivation**

- Too many solvers
- Creates redundant work
- Want one optimization target
- Want two-way interaction between all object types





### **Core Idea**

# Everything is a set of particles connected by constraints

# **Advantages**

- Simplifies collision detection
- Stable two-way interaction of all object types:
  - Rigid Bodies
  - Deformables
  - Liquids
  - Cloth
- Fits well on the GPU

### **Particles**

# struct Particle { float pos[3]; float vel[3]; float invMass; int phase; };

Phase-ID used to control collision filtering
Single collision radius





### Constraints

### Constraint types:

- Distance (clothing)
- Shape (rigids, soft bodies, plastics)
- Density (fluids)
- Volume (inflatables)
- Contact (non-penetration, friction)
- Combine constraints to create wide variety of effects
  - Melting, phase-changes
  - Stiff cloth



# FleX new features

- New buffer-centric API
- New collision shape API
- Add support for CUDA 8.0
- Add support for D3D 11/D3D12
- Local space simulation

### Local Space Simulation

Particles inside an attached parent frame are updated by inertial forces

Without

www.fraps.com



www.fraps.com



# **Enable Local Space Simulation in UE4**

### Step 1

Make the FleX component a child of the object it should be parented to



# Enable Local Space Simulation in UE4 cont.

### Step 2

Enable the Local Space simulation option on the FleX component

⊿ Flex		
Override Asset	<b>2</b>	
Container Template	flexClothCon 👻 🌩 🔎	Ð
D Phase		
Mass	1.0	
Attach to Rigids	2	
Inflatable Pressure Multiplier	1.0	
Tearing Max Strain Multiplier	1.0	
Local Space	29	
▲ Inertial Scale	Ċ	
Linear Inertial Scale	0.25 💽 🕤	
Angular Inertial Scale	0.25 🔊 🖻	

# Enable Local Space Simulation in UE4 cont.

Step 3

Enable Is FleX Parent on the parent object



# Enable Local Space Simulation in UE4 cont.

### Step 4

Set the linear and rotational inertial strengths

⊿ Flex		
Override Asset	<b>2 2</b>	
Container Template	flexClothCon 👻 🔶	D D
D Phase		
Mass	1.0	•
Attach to Rigids		
Inflatable Pressure Multiplier	1.0	
Tearing Max Strain Multiplier	1.0	•
Local Space	2 5	
▲ Inertial Scale	5	
Linear Inertial Scale	0.25	
Angular Inertial Scale	0.25	1 -
Angular Inertial Scale	0.25	



### **Global Space Simulation**

### Local Space Simulation



# **UE4-FleX Cloth**

- Environmental cloth
- CCD Triangle Tests
- Auto-attachment to static or dynamic actors
- Inflatable constraints



# **UE4-FleX Ropes**

- Based on built-in
   UCableComponent
- Supports bending / selfcollision / world collision



# **UE4-FleX Force Fields**

- Integration with UE4 URadialForceComponent
- Scriptable with Blueprints
- Applied in CUDA through FleXExtensions



# Interop between PhysX

- Two-way interaction between FleX<->PhysX
- FleX actors insert bounds into PhysX scene
- Overlap query per-FleX Actor
- Allows CCT to interact with FleX objects



### Create a simple cloth demo with UE4-FleX



### **Overview**

- GPU Rigid Bodies (GRB)
- FleX
- Flow
- WaveWorks

# **UE4-Flow Demo**



### **FLOW**

### Features:

- Combustible fluid, fire and smoke
- Dynamic grid simulator
- D3D11 and D3D12 support
- Volume rendering





### **NVIDIA Flow In Unreal Engine 4**

### Create a grid





### **NVIDIA Flow In Unreal Engine 4 cont.**

### Create an emitter



⊿ Emitter	
▷ Linear Velocity	X 0.0 V 0.0 V Z 0.0 V
Angular Velocity	X 0.0 V 0.0 V Z 0.0 V
Blend in Physical Velocity	1.0
Smoke	0.5
Temperature	2.0
Fuel	1.0
Fuel Release Temp	0.1
Fuel Release	0.0
Allocation Predict	0,125
Allocation Scale	1.0
Collision Factor	0.0
Emitter Inflate	0.0
Couple Rate	0.5
Velocity Mask	1.0
Smoke Mask	1.0
Temperature Mask	1.0
Fuel Mask	1.0
Num Substeps	
Alloc Shape Only	
Use Distance Field	
⊿ Grid	
Flow Material	None 🔸 🔶 🔎

### NVIDIA Flow In Unreal Engine 4 cont.

### Setup Flow Material and Flow Render Material

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### Create a simple fire demo with UE4-Flow



### **Overview**

- GPU Rigid Bodies (GRB)
- FleX
- Flow
- WaveWorks

### Agenda

- UE4 WaveWorks Overview
- UE4 WaveWorks key features
- UE4 WaveWorks core components introduction
- How to use WaveWorks in UE4



### **UE4 WaveWorks Overview**

- Enable developers to deliver a cinematic-quality ocean simulation for interactive applications
- Integrated to UE4 now
- Completed tools to create ocean and lake
- More features are coming ...



https://www.youtube.com/watch?v=DhrNvZLPBGE

# **Key Features**

- Completed ocean's simulation and rendering systems
  - Foam's simulation and rendering
- Shoreline effect
- Realtime physics feedback
- Tessellation
- Quad-tree tile-based LoDing
- Also can be used to create lake

# WaveWorks Asset

- Create WaveWorks Asset
- WaveWorks Asset details panel
  - WaveWorks simulation parameters
  - Shoreline parameters



Simulation	
Detail Level	Extreme 👻 🗢
FFTPeriod	400.0 🔊 🗅
Use Beaufort Scale	
Readback Displacements	
Aniso Level	16 💽 🗅
Parameters	
Time Scale	1.0
Wind Direction	X 0.8 Y 0.6 Y
Wind Speed	8.0
Beaufort Scale	3.8 🔊 🤉
Wind Dependency	0.98
Small Wave Fraction	0.0
Wave Amplitude	0.9446
Choppy Scale	0.935216
Foam Generation Threshold	0.470917
Foam Generation Amount	0.541284
Foam Dissipation Speed	0.370642 🔊
Foam Falloff Speed	0.091743
Shoreline	
Use Shoreline	✓ p
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### WaveWorks Actor, Component



WaveWorks Actor

### WaveWorks Component

# Shoreline

- Distance Field Texture
  - R: distance to shoreline
  - G: depth
  - B,A: gradient



# Shoreline

- Create Distance Field Texture
  - Set Capture Actor's Position
  - Fill the parameters
  - Click "Capture Scene" button



### WaveWorksShorelineCaptureComponent

# Rendering

- Ocean's Rendering
  - Reflection
  - Refraction
  - Specular
  - Foam



# Rendering

### WaveWorks material node

- Foam attributes
- World normal
- Un-displaced world position
- Vertex's displacement
- Distance to shoreline



# **Physics Feedback**

- Sample displacement
- Get intersection point between ray and ocean



# WaveWorksStaticMesh Component



WaveWorks StaticMeshComponent



### Workflow in UE4



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### Join the GameWorks developer program

If you don't have an account on developer.nvidia.com or are not a registered member of the NVIDIA GameWorks developer program then register here:

http://developer.nvidia.com/registered-developer-programs

If you are logged in, accept the EULA and enter your GitHub username at the bottom of the form: https://developer.nvidia.com/gameworks-source-github



### https://github.com/NvPhysX/UnrealEngine/tree/WaveWorks-4.16

Branch: WaveWorks-4.16 - New pull requi	est	Create new file Upload file	s Find file Clone or download -
This branch is 18 commits ahead, 89 com	mits behind EpicGames:release.		গী Pull request  🖹 Compare
<b>jackran111</b> update README.md			Latest commit 9b4c758 an hour ago
Engine	fix bug : switch waveworks detail level to normal c	ause crash	an hour ago
Samples	Copying //UE4/Release-Staging-4.14 to //UE4/Dev	v-Main (Source: //UE4/R	8 months ago
Templates	Updating config ini on some templates to include	ResetVR input to res	3 months ago
WaveworksTester	Add a floating sphere BP		9 days ago
.gitattributes	Engine source (4.0 branch up to CL 2027741)		3 years ago
.gitignore	Copying //UE4/Dev-Platform to Dev-Main (//UE4/	/Dev-Main)	5 months ago
GenerateProjectFiles.bat	Copying //UE4/Dev-Mobile to //UE4/Dev-Main (S	ource: //UE4/Dev-Mobile	7 months ago
GenerateProjectFiles.command	Updating copyright notices to 2017 (copying from	n //Tasks/UE4/Dev-Copy	7 months ago
GenerateProjectFiles.sh	Updating copyright notices to 2017 (copying from	n //Tasks/UE4/Dev-Copy	7 months ago
LICENSE.md	Always reference the latest EULA from GitHub rath	ner than including a	3 months ago
README.md	update README.md		an hour ago
Setup.bat	Don't append theprompt argument to GitDepe	ndencies.exe if it's alr	2 years ago
Setup.command	Updating copyright notices to 2017 (copying from	n //Tasks/UE4/Dev-Copy	7 months ago
Setup.sh	Updating copyright notices to 2017 (copying from	n //Tasks/UE4/Dev-Copy	7 months ago
UE4Games.uprojectdirs	PR #877: Fix typo (Contributed by DaJoker29)		2 years ago