Visualizing Flow Conditions Using a Stream Digital Twin

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Purpose of the Stream Digital Twin

- Realistic visualizations of IRL streams & watersheds undergoing a variety of anticipated flow and flood conditions.

- Intended to aid planning and decision-making processes.

- NOT intended as a scientific simulation of the origins or consequences of flooding.

This is a Work In Progress. Many details of the workflow are still in flux.
Assembling the Stream Digital Twin

1. Capture detailed landscape of the stream bed.
2. Run water simulations through the stream bed.
3. Convert water simulation data into water volume data.
4. Run surface wave simulations on top of the water volume.
5. Combine landscape, water volume, and surface waves in realistic rendering of the scene.
Processing Flow

EISL

Terrain Capture
iPad Pro
Drone
360 camera

Geometry & Texture Generation
Commercial Photogrammetry Software

Water Simulation Via Smoothed Particle Hydrodynamics
Water Visualization (Diagnostic)

Convert Simulation to Volume

Surface Wave Simulation on Top of Water Volume

Virtual Camera Tracking
Physically Realistic Render of Scene With Many Cameras including “Live Gaze” camera

Video display

“Live Gaze” video display

Gilligan Environmental Digital Twin Simulator

Video display
Terrain Capture

- iPad Pro lidar and camera + photogrammetry processing
- Drone multiple cameras + photogrammetry processing
GEOMETRY FROM IPAD CAPTURE
Background via 360 degree Camera
Smoothed Particle Hydrodynamics

- Large number of interacting particles
- Interactions patterned after fluid dynamics equations
- More particles -> more accurate fluid
- Highly flexible
- Well suited to irregular domains like stream beds
- Stability issues

Interactive 2D SPH Simulation with Mouse-Injected Particles

20,000 particles in 2D
Demonstration: Medium Water Level

Water Volume Derived From the Simulation (Work In Progress)
Demonstration: Higher Water Level

Water Volume Derived From the Simulation (Work In Progress)
GILLIGAN: Environmental digital twin for prototyping & visualization

- Oceanscapes
- Clouds
- Cloudscapes
- Splashing and whitewater
- Ship wakes
- Ship dynamics
- Black hole gravitational lensing
- Game engines
- Image assembly
- DCC INTEGRATION FRAMEWORKS
- NIWC FRAMEWORK
- PYTHON FRAMEWORK
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New capabilities for stream visualization

Terrain Import, Edit, and Render

Water Simulation via Smoothed Particle Hydrodynamics

Convert Simulation to Water Volume

... and more
Currently Functioning vs Work In Progress

- **Working:**
  - Terrain import
  - sph water simulation
  - Virtual camera walkthroughs

- **Working with significant variations:**
  - Water volume conversion

- **Work In Progress:**
  - Surface waves
  - Turbidity optics
  - “Live Gaze” 360 video playback

- **Things that would be nice in the future:**
  - Better sph incompressibility
  - Splashing and whitewater
  - Floaters
  - Wet/dry optical properties
Surface Waves Simulated on Top of 3D Water

Life of Pi

The Hobbit: Desolation of Smaug
Life of Pi
The Hobbit: Desolation of Smaug
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