

CS354P

DR SARAH ABRAHAM

FUTURE OF GAME ENGINES

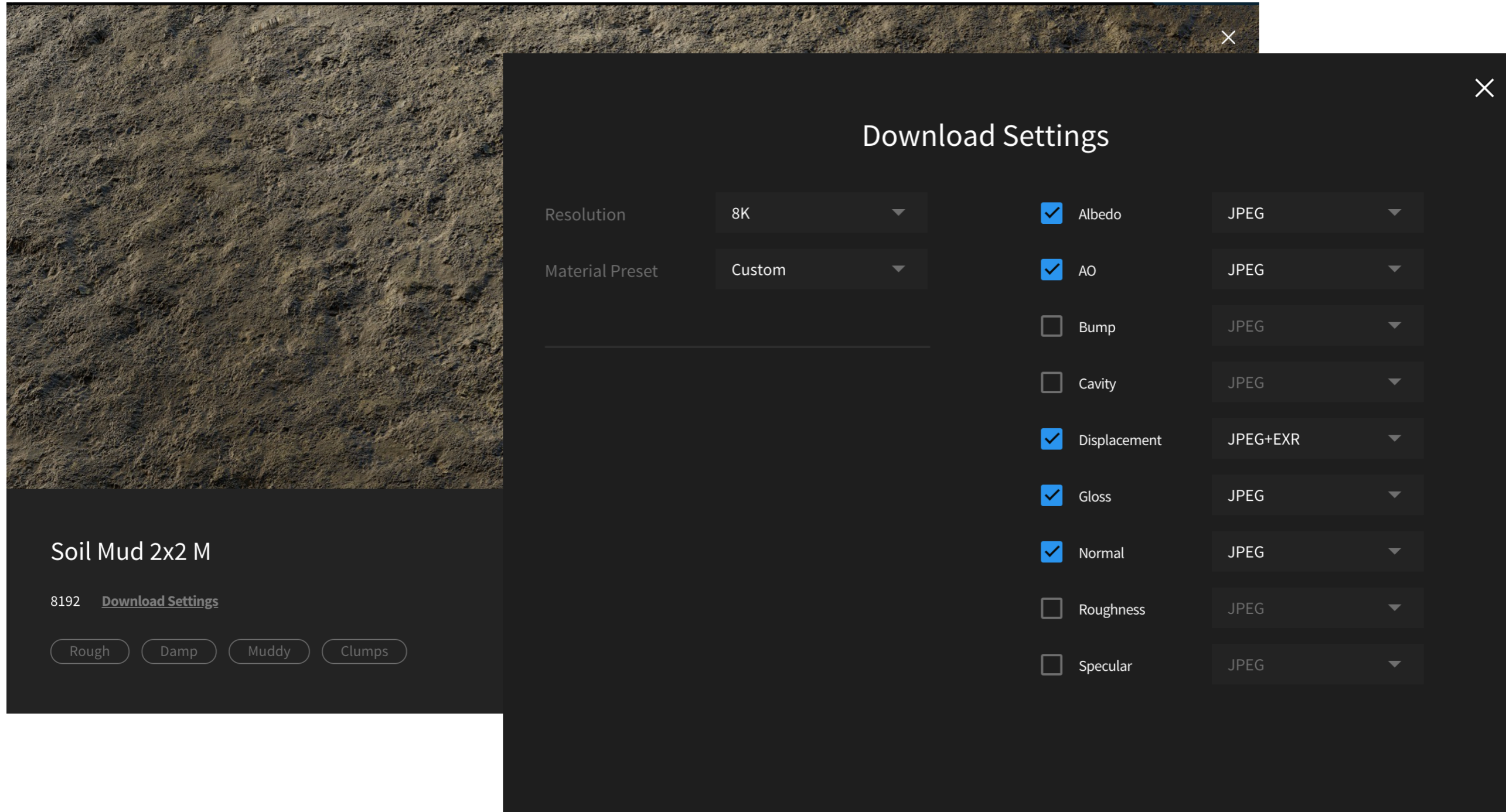
UE5 DEMO



PHOTOGRAMMETRY

- ▶ Area of using photographic data to understand physical properties of a scene
 - ▶ e.g. extracting 3D distances, extracting material properties, etc
- ▶ Photographic data is captured at an extremely high resolution
 - ▶ Offline productions can use that data as-is
 - ▶ Real-time productions traditionally lower resolutions and use displacement/normal maps to capture geometry with fewer polygons

PHOTOGRAMMETRY EXAMPLE



The image shows a screenshot of a 3D asset viewer interface. On the left, there is a large, high-resolution texture of soil. Below the texture, the text "Soil Mud 2x2 M" is displayed, along with a small number "8192" and a link to "Download Settings". Below this, there are four buttons labeled "Rough", "Damp", "Muddy", and "Clumps". On the right, a "Download Settings" panel is open, showing various options for downloading the asset. The panel includes a "Resolution" dropdown set to "8K" and a "Material Preset" dropdown set to "Custom". Below these are several checkboxes for different data channels: "Albedo" (checked), "AO" (checked), "Bump" (unchecked), "Cavity" (unchecked), "Displacement" (checked), "Gloss" (checked), "Normal" (checked), "Roughness" (unchecked), and "Specular" (unchecked). To the right of each checkbox is a dropdown menu for the file format, with "JPEG" selected for most channels and "JPEG+EXR" selected for "Displacement".

VIRTUAL TEXTURING

- ▶ Allows for use of very large textures with smaller memory footprint at runtime
- ▶ Similar concept as mipmapping but only run on **visible pixels**
- ▶ Mipmaps split into tiles of a fixed size and GPU determines which of the fixed tiles to load
- ▶ Runtime Virtual Textures (RVT)
 - ▶ Texel data generated by GPU at runtime
- ▶ Streaming Virtual Textures (SVT)
 - ▶ Texel data cooked and loaded from disk
 - ▶ Used for pre-baked lightmaps

NANITE

- ▶ “Virtualized Micropolygon Geometry”
- ▶ Allows direct importing of high-quality geometry with material info
- ▶ Streamed and scaled in real-time
- ▶ Handles normal maps and LODS (level of detail) without manual authoring
- ▶ Effectively, this performs what mesh decimation tools like Simplygon does without offline bakes, user input, or data loss

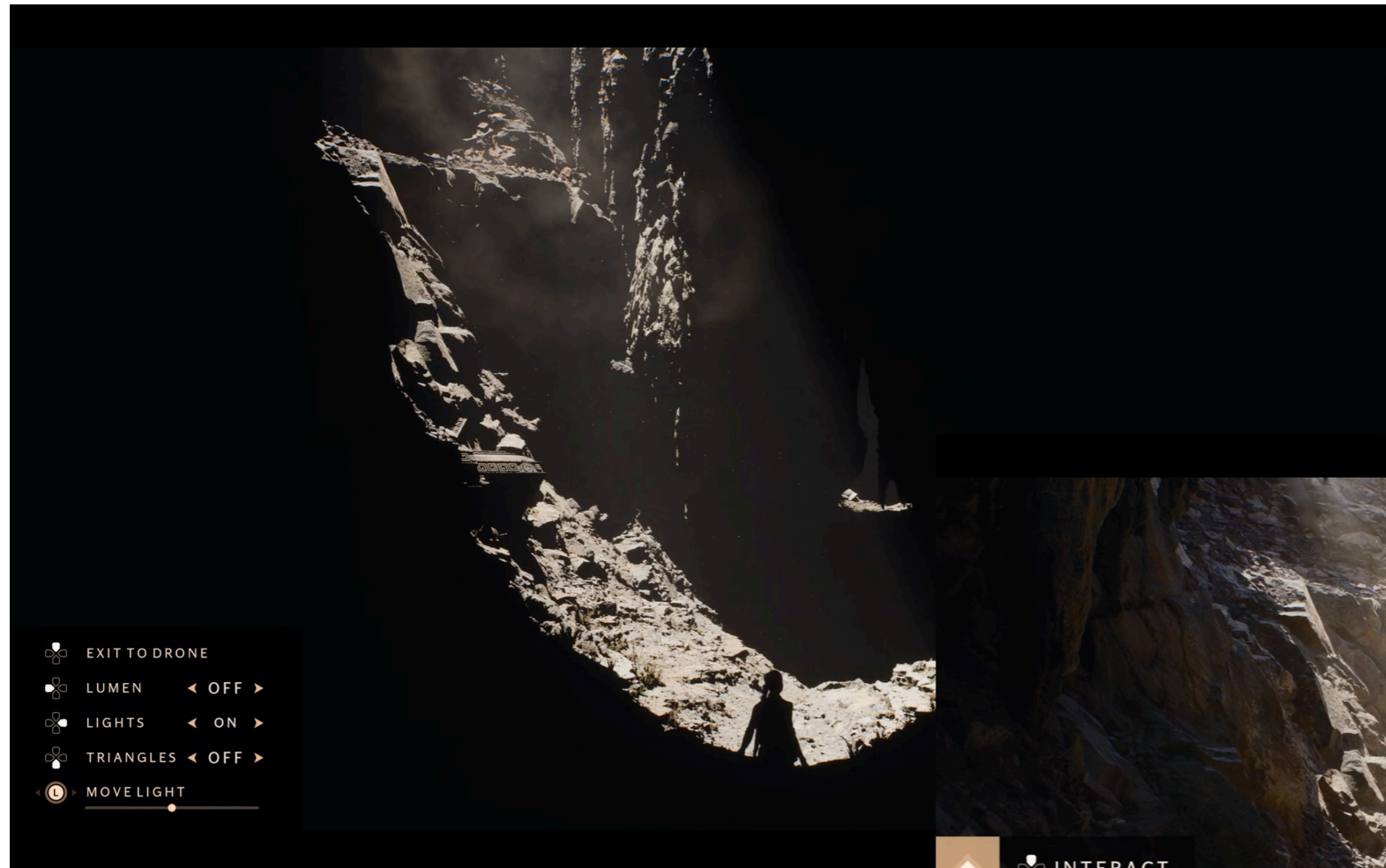
HIGH-RESOLUTION RENDERING

- ▶ Nanite reduces $>1\text{B}$ in source geometry to $\sim 20\text{M}$ drawn triangles
- ▶ For reference:
 - ▶ inFAMOUS (2014) has 11M drawn tris (PS4)
 - ▶ Street Fighter V (2016) has 900k drawn tris (PS4)
 - ▶ FFXV (2016) has 5M drawn tris (PS4)
 - ▶ The Division (2016) has 5M-6M drawn tris (PC)
 - ▶ Star Citizen (2019) has 30M drawn tris (PC)

LUMEN

- ▶ Fully dynamic global illumination system
- ▶ Handles diffuse inter-reflection (color bleed) and indirect specular reflections
- ▶ No pre-baked lightmaps

DIRECT VERSUS INDIRECT ILLUMINATION



Light coming from light source



Light coming from secondary bounces

HOW BIG OF A DEAL IS THIS?

- ▶ It is a big deal but not unprecedented
 - ▶ Likely based on VXGI which is NVidia's voxel-based real-time renderer



HOW BIG OF A DEAL IS THIS?

- ▶ It is an enormous deal for how much it simplifies the art pipeline
 - ▶ Artists spend a large portion of their time “retopping” (re-topologizing) assets to fit within a memory budget
 - ▶ Pre-baked lighting takes a long time and a lot of resources
- ▶ Allows artists to focus on “art” side of creation rather than technical issues

CONVOLUTION REVERB

- ▶ Signal processing technique to capture physical properties of location for sound playback
 - ▶ More accurate sounds based on the space
- ▶ Traditionally required offline processing but done in real-time with the advent of better hardware acceleration

IK AND CONTEXTUAL ANIMATIONS

- ▶ IK (Inverse Kinematics) handle adjustments to joint angles based on a target position
 - ▶ Does not necessarily provide a “natural” solution to this problem
- ▶ Motion warping and contextual triggers allow for better-looking solutions and more natural combinations of animations
 - ▶ Not new concepts but improvements to the existing UE4 toolset

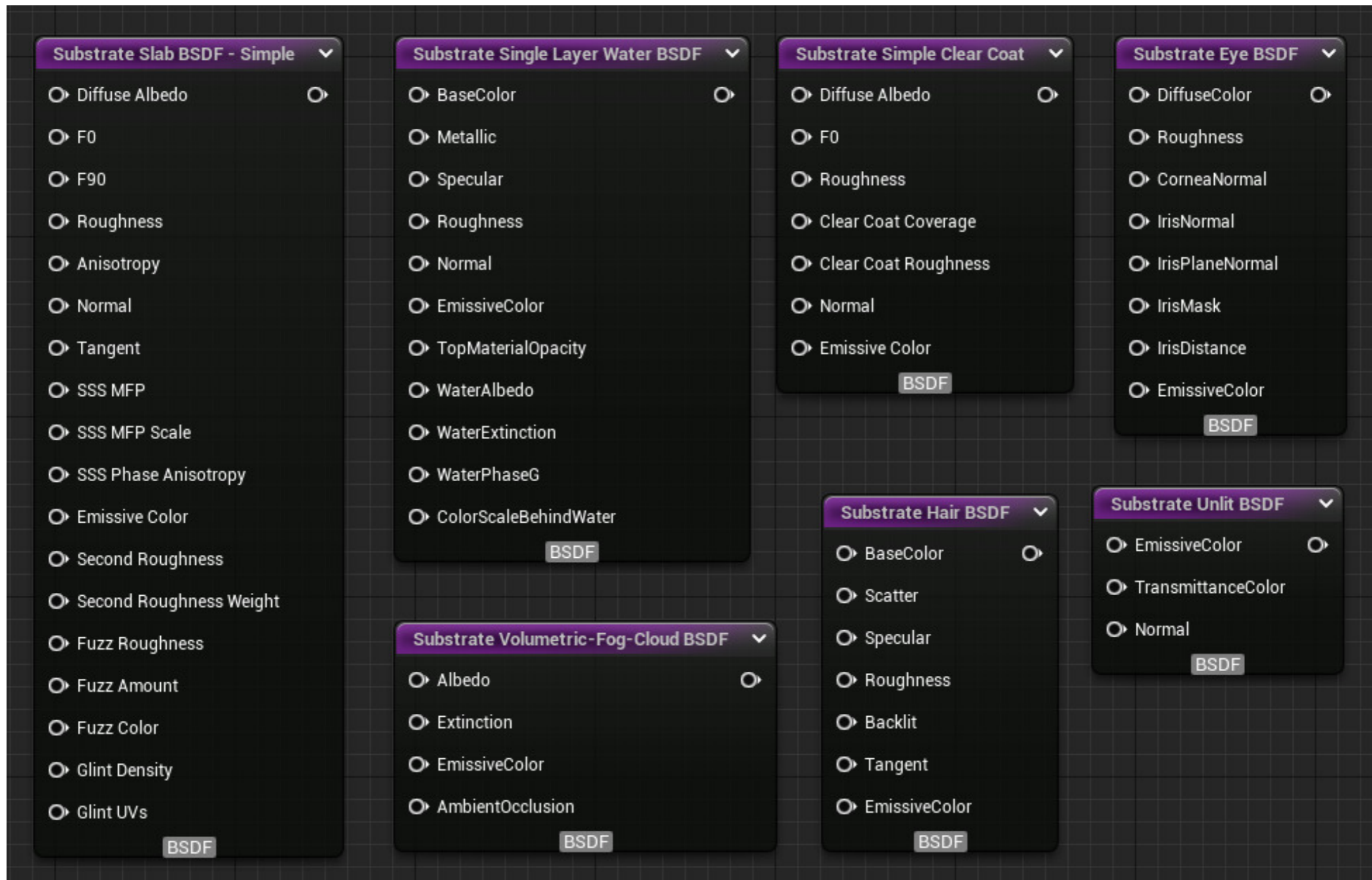
UE5.2 TECH DEMO



SUBSTRATE MATERIALS

- ▶ More flexible composition of materials and parameterization
 - ▶ Replaces the fixed suite of shading models and blend modes
- ▶ Treats layers of materials as “slabs of matter”
 - ▶ Use of BSDFs (bidirectional scattering distribution functions) to encode physically-based properties of the matter
 - ▶ Lighting models will interacting in a physically-based way
- ▶ Model can be simplified/modified in a principled way for performance or non-physically-based rendering

SUBSTRATE BSDFs



HOW BIG OF A DEAL IS THIS?

- ▶ It is a substantial improvement toward real-time physically-based rendering
 - ▶ Allows artists with a deep understanding of lighting models to create material variance in a principled way
 - ▶ Relies on existing Unreal shader pipeline which does not require extensive shader programming to achieve effects

PROCEDURAL SYSTEMS

- ▶ Use of mathematical functions to create assets in a controllable, deterministic, but random way
- ▶ Artists create limited set of assets the procedurally generate scenes/new assets
 - ▶ Can define rules for the system
 - ▶ Can use noise functions to randomize according to a deterministic seed

HOW BIG OF A DEAL IS THIS?

- ▶ It's a pretty big deal
 - ▶ Procedural generation is of the most important areas in the artist pipeline given the expected scope of modern games
 - ▶ Being built in directly to Unreal allows for a more efficient system/easier integration
- ▶ But these technical concepts of procedural generation already exist in other applications (e.g. Houdini)

HOUDINI PLUGIN DEMO

- ▶ Procedural house generation: <https://www.youtube.com/watch?v=oXowXS9Pj2A>



WHO DOES THIS IMPACT?

- ▶ Triple A development
 - ▶ Unreal is an “off-the-shelf” competitor to notable high-end game engines such as EA’s Frostbite or Guerrilla Games’ Decima
- ▶ Indie development
 - ▶ Faster art pipeline is good for teams of all sizes
- ▶ Artists and creatives
 - ▶ May represent a change in how developers think about building out an art pipeline

REFERENCES

- ▶ UE5 Announcement <<https://www.unrealengine.com/en-US/blog/a-first-look-at-unreal-engine-5>>
- ▶ VXGI <<https://developer.nvidia.com/vxgi>>
- ▶ Polycount <<https://polycount.com/discussion/141061/polycounts-in-next-gen-games-thread>>