Deformable Snow Rendering in Batman™: Arkham Origins

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Agenda

- **Motivations**
- **Deformable Snow**
  - Novel technique for rendering of surfaces covered with fallen deformable snow
  - For consoles and enhanced for PC (DX11 tessellation)
- **Q&A**

THERE'S ALWAYS TIME FOR A...
Soder!

GAS

Motivations

- Enhance the world with dynamics of deformable snow
- Three requirements:
  1. **Iconic visuals** of deformable snow
  2. **Organic deformation** from walking, falling, sliding, fighting and more
  3. **Low memory usage** and **low performance cost** for an open world game

Iconic / Organic Deformable Snow

From Google Images - http://bit.ly/M7T9kV (footsteps in snow, left) and http://bit.ly/M7TbJB (snow angel, right)

Previous Work?

[St-Amour 2013] (Assassin's Creed 3)
[Edwards 2012] (Journey)

➢ Raycast on a terrain / Modify terrain mesh.
  - We don't have terrain. We have rooftops and streets.
  - Besides, we don't want to add raycasts.

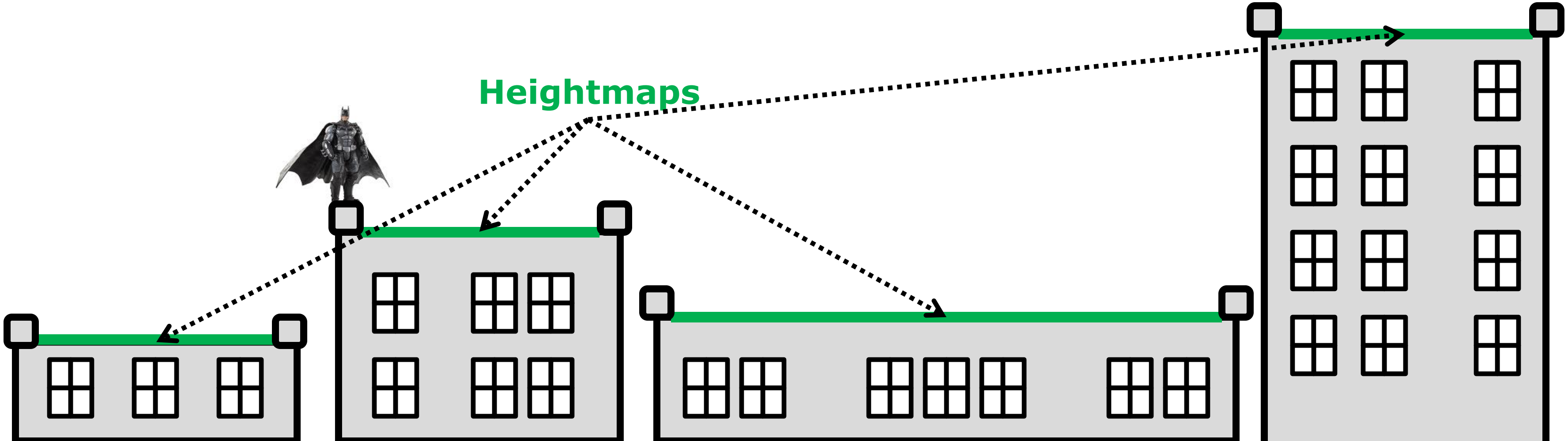
➢ Requires variable triangle density for visually convincing vertex displacement in all cases
  - PC DX11 with tessellation is great… but what about consoles? ☹

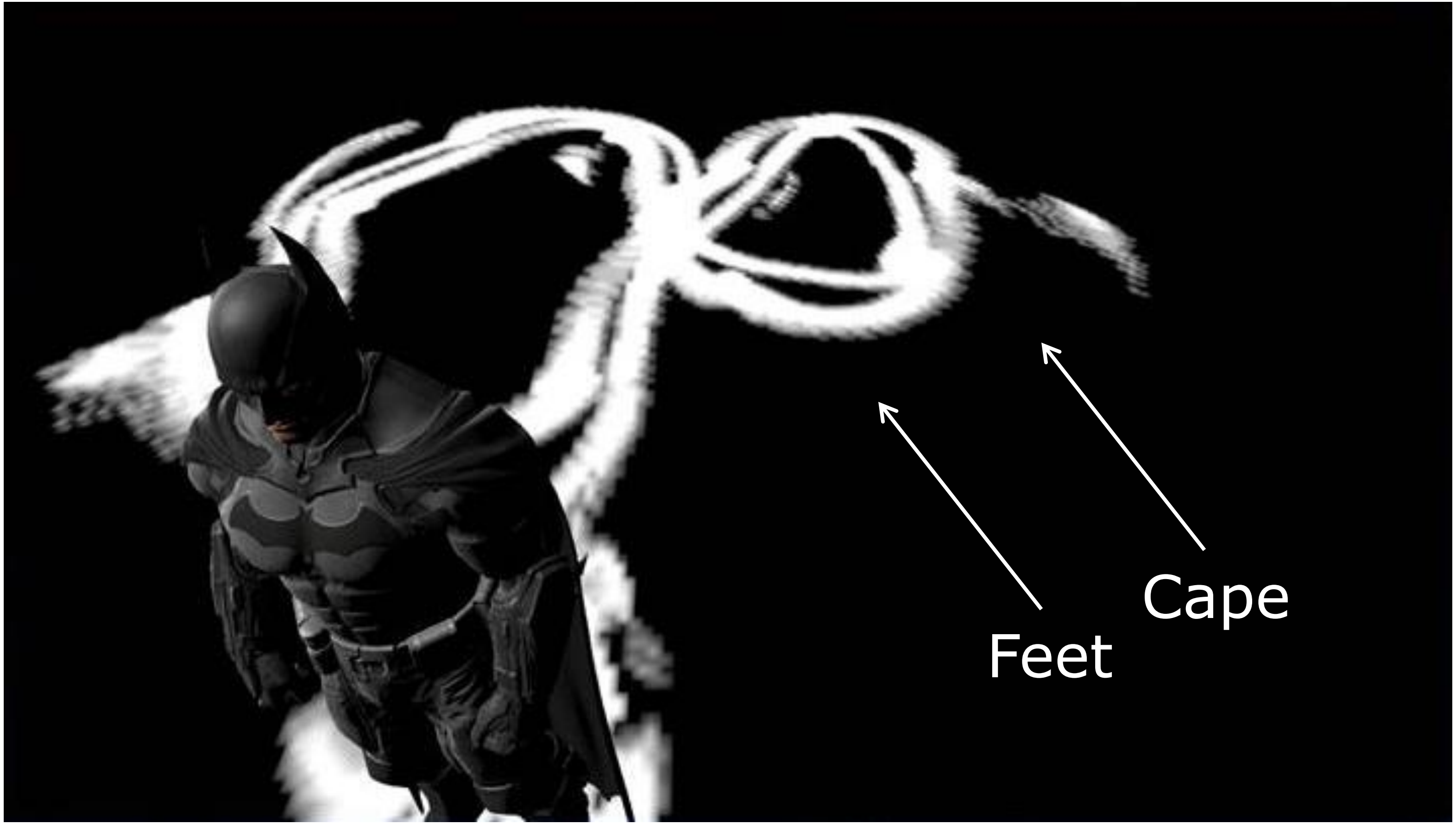
Our Approach (1/)

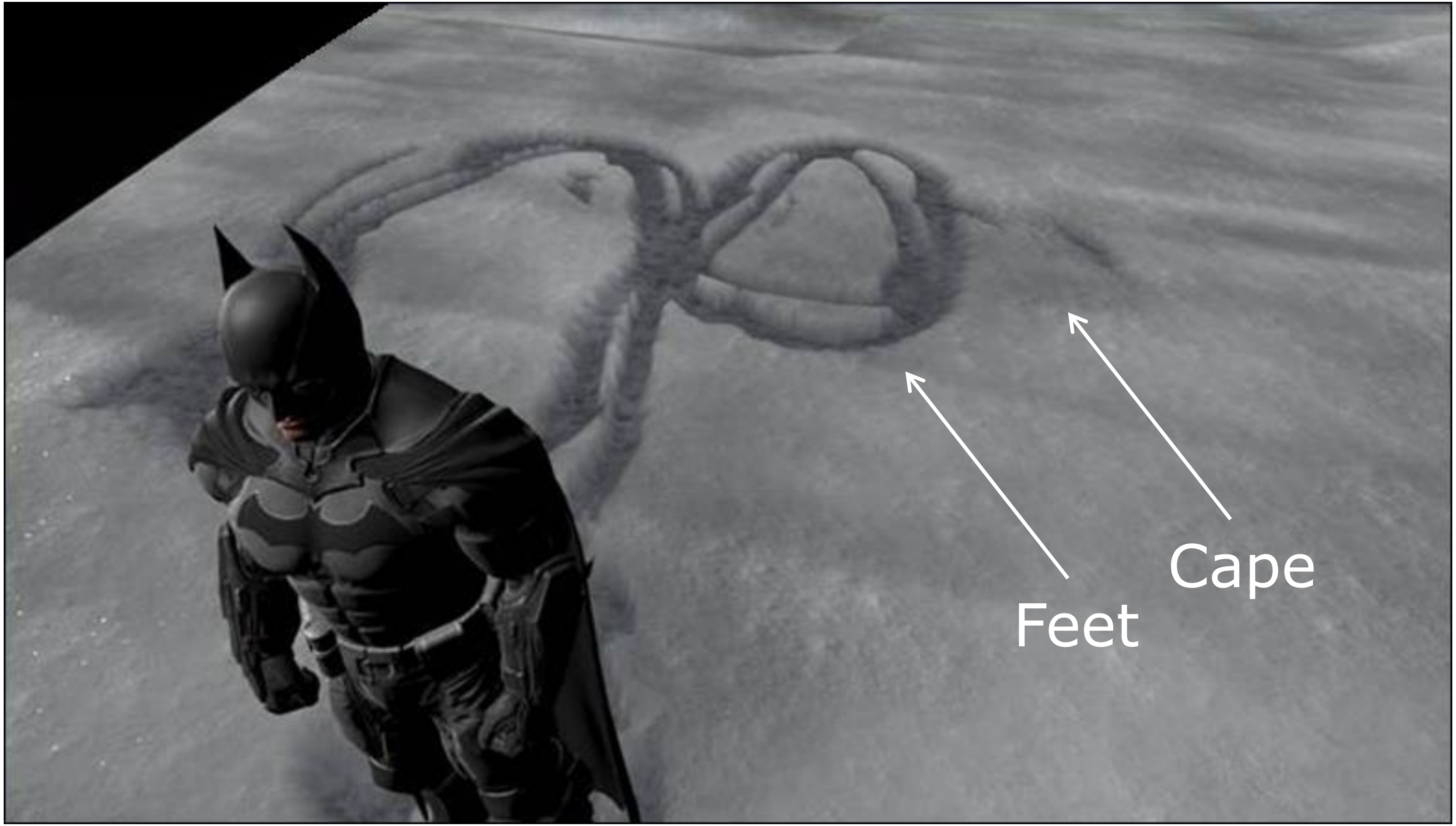
- Generate displacement heightmaps at runtime
    - Snow prints are a semi-low frequency detail effect
    - Cheap approximation works with **footsteps & more**
    - Great performance, and low memory usage
- Consoles: virtual displacement via *Relief Mapping*
    - Minimal taps. No “swimming”
    - Independent of triangle density
- PC: DirectX 11 version with tessellation

Our Approach (2/)

- Gotham has many rooftops and streets
- Dynamically alloc/dealloc heightmaps based on size, player/AIs and visibility

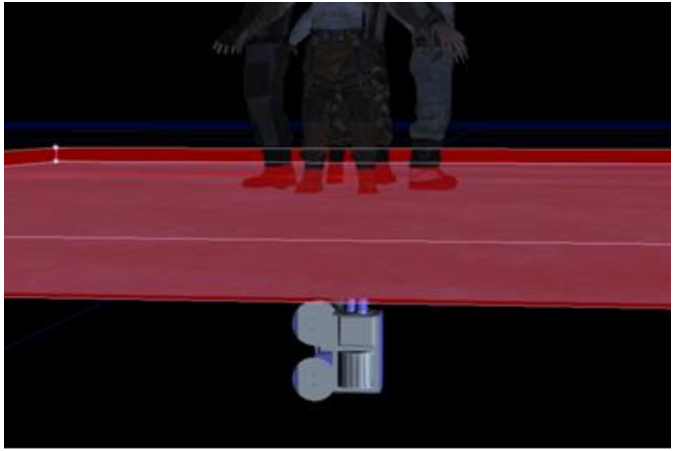



Cape
Feet


Cape
Feet

Generating the Heightmap ?

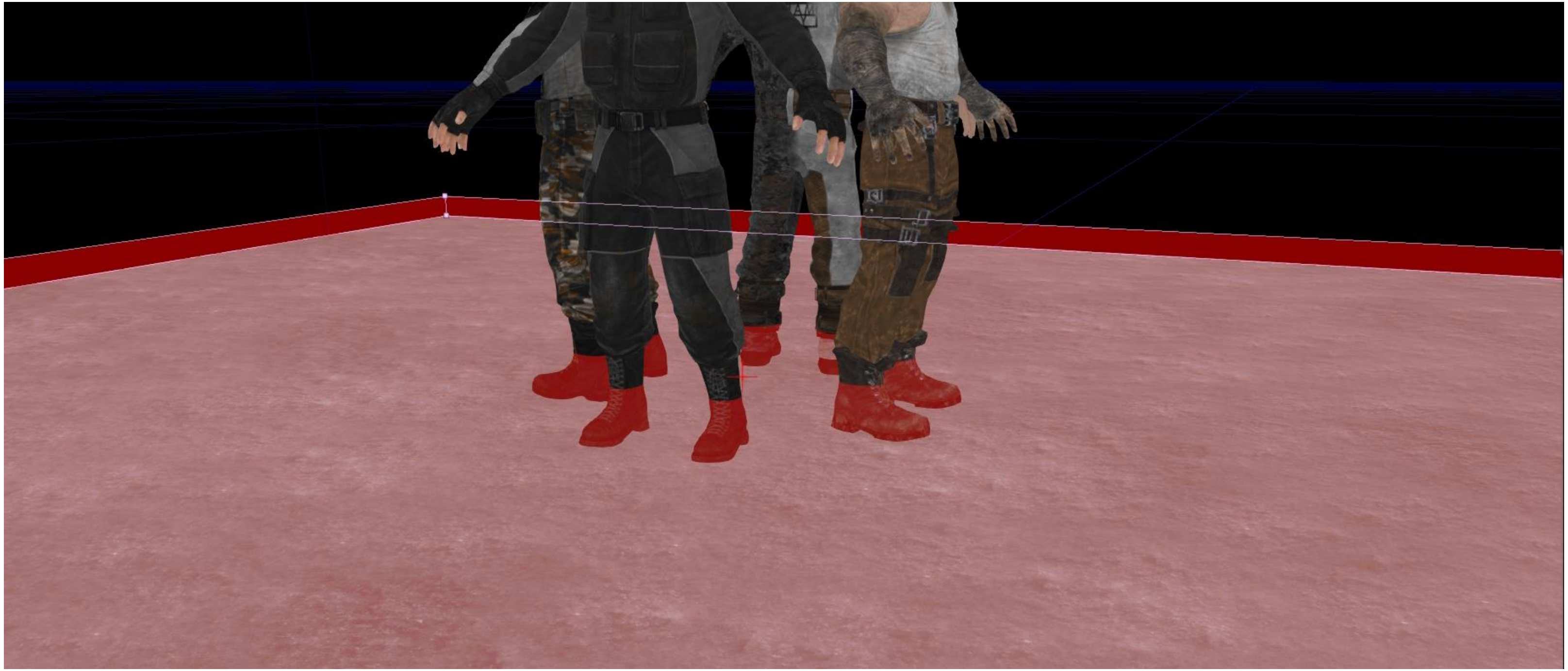
- Render snow-affecting objects looking from under the surface using an ankle-high orthogonal frustum

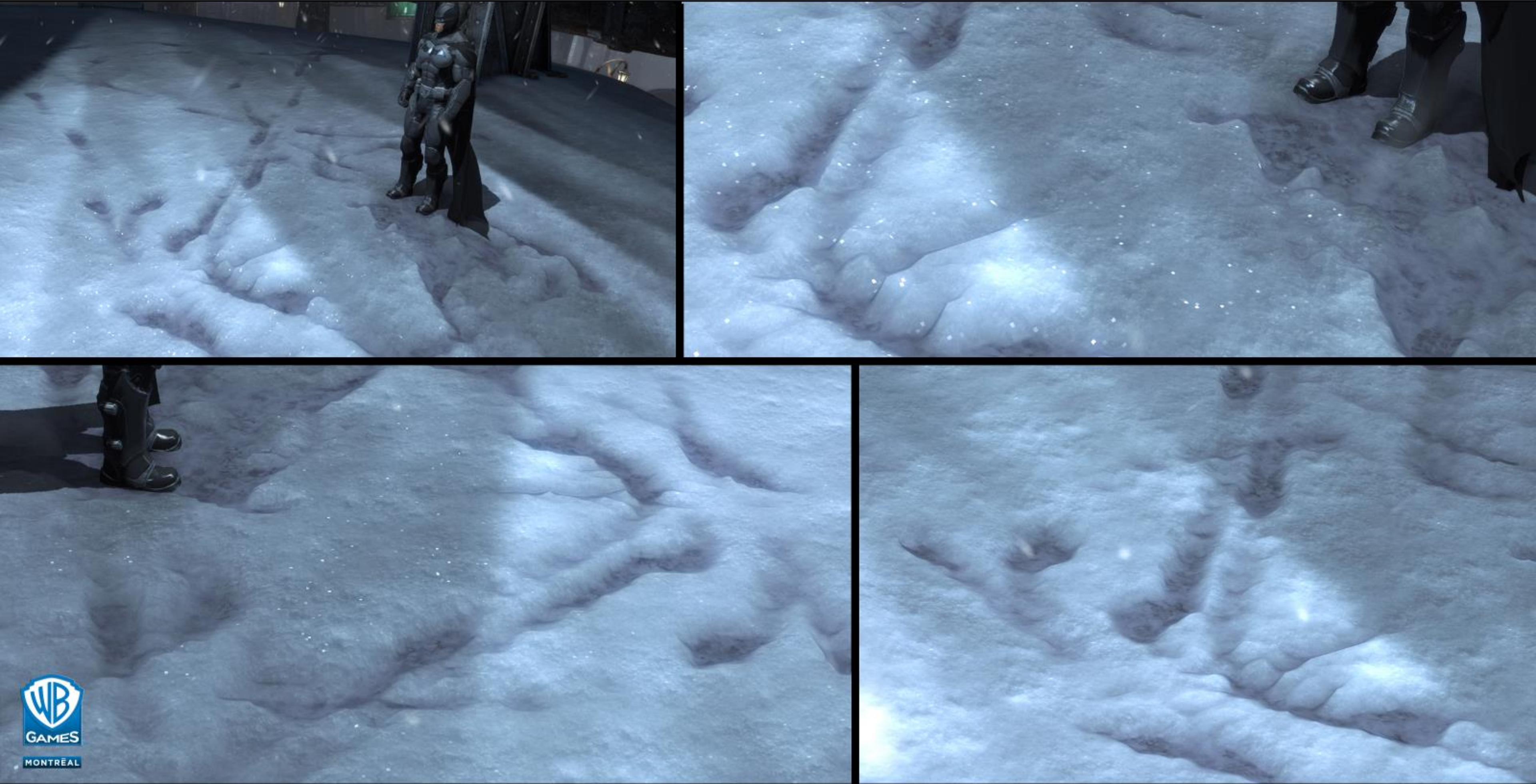


1. Clear to black
2. Render actors in white
3. Filter and accumulate (ping/pong) in a texture

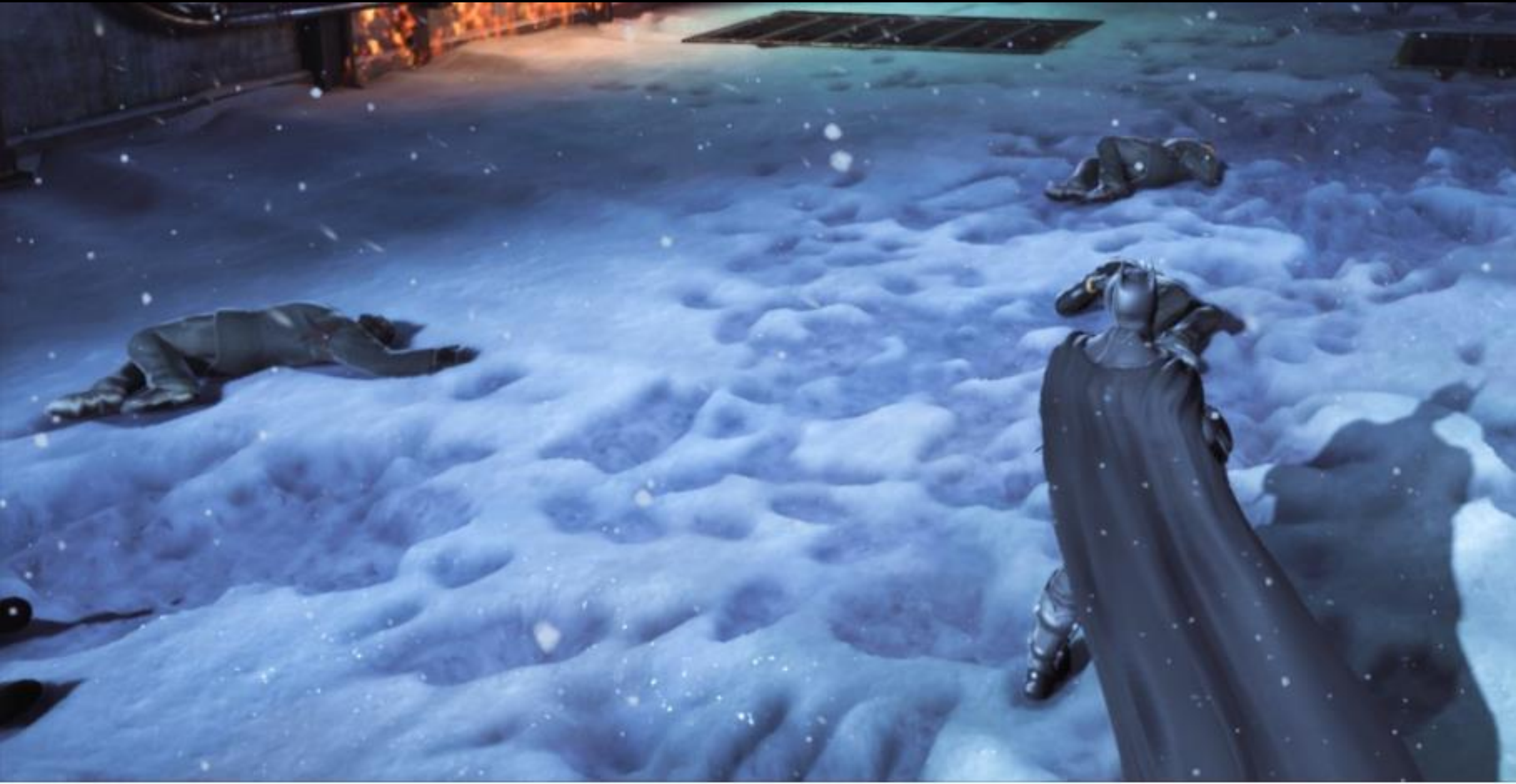
- Anything in that zone will affect the heightmap (feet, hands, sliding, throwing a thug to the ground…)

Ankle-high Orthogonal Frustum





WB
GAMES
MONTRÉAL



Let’s see what it looks like at runtime!

Update Loop

For every active* snow surface

1. Figure out if surface-affecting object is on the surface

-We use a quad tree look-up rather than keeping an actor list for each surface

2. Override materials on all parts

- Simple white material

3. Render actors

4. Process/Accumulate with custom post-process chain

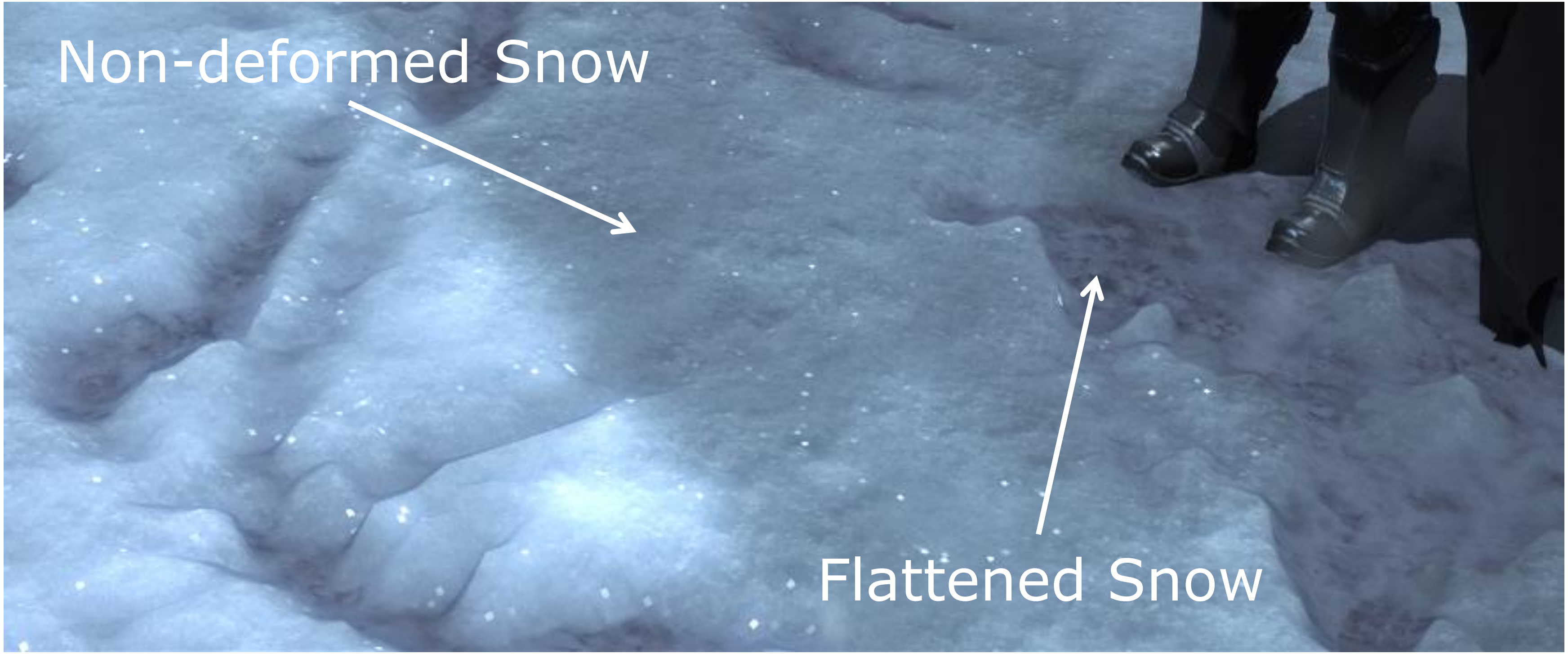
Heightmap Accumulation & Render

- **Stage 1** – Get results & small blur
  - 4-tap bilinear Poisson
- **Stage 2** – Add to existing heightmap
  - During this stage, you can also subtract a small value to the heightmap to make snow gradually replenish (since it’s snowing) ☺
- **Stage 3** – Shading

Stage 3 - Shading (1/)

- **Snow surfaces have 2 material options**
  1. *Basic Snow Material*
     - Active when surface is not being deformed
     - Shows new / clean / untouched snow, cheaper
  2. *Deformable Snow Material*
     - Two stages: non-deformed or fully flattened snow
     - Non-deformed part the same as *Basic Snow Material*
     - Fully flattened shows rooftop tiles / concrete.
     - Blends both stages using heightmap & Relief Mapping

Stage 3 - Shading (2/)

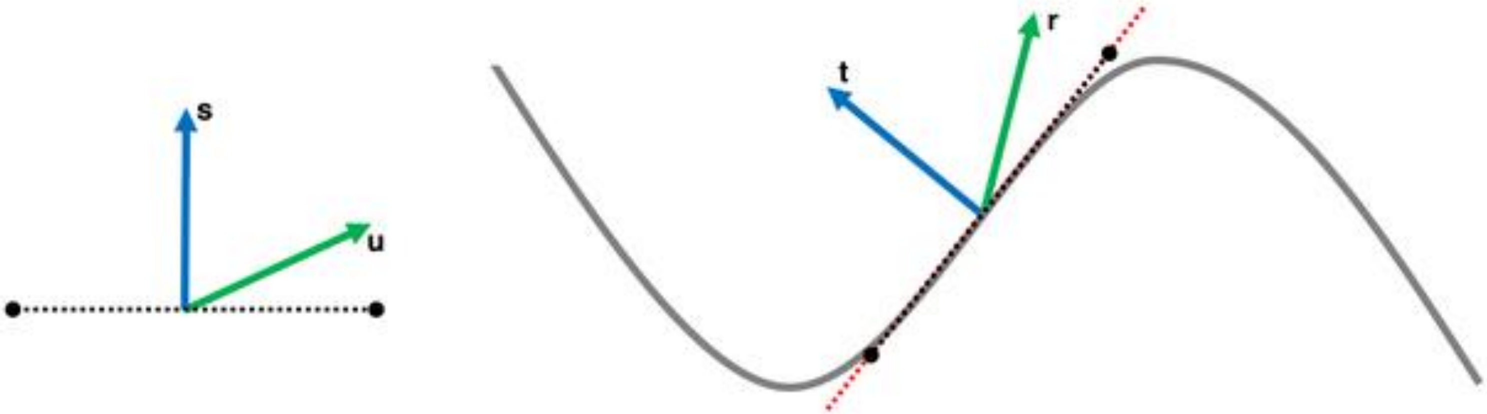


Stage 3 - Shading (3/)

➢ Blending Material Stages

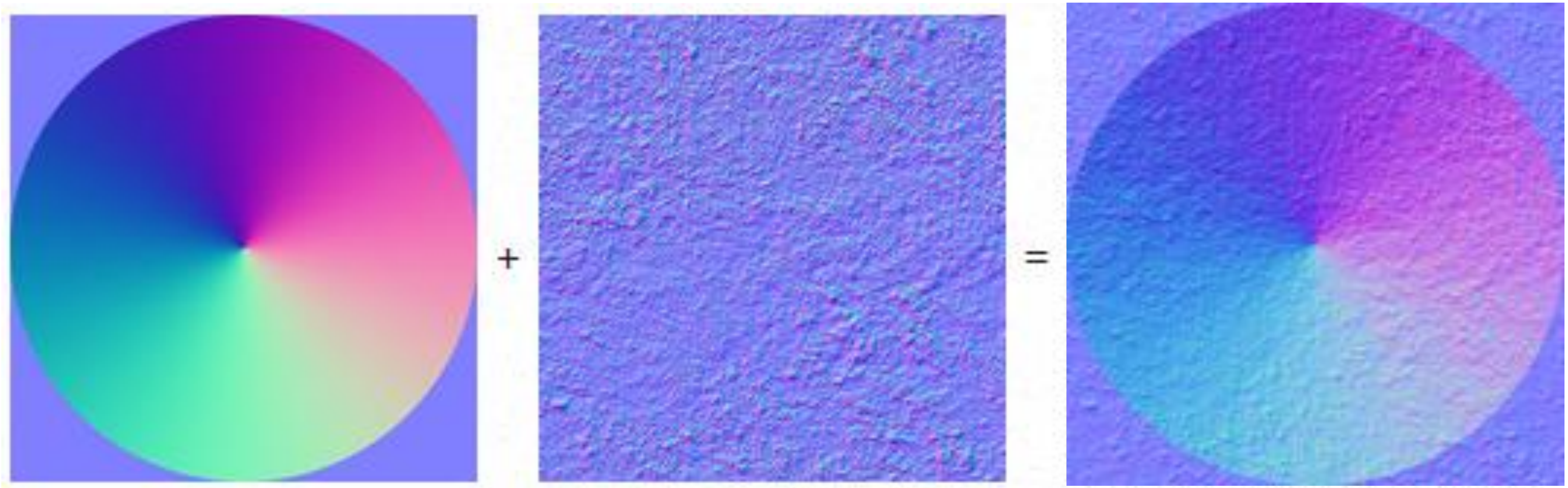
- For diffuse & spec, simple lerp
  - Also, tint diffuse with sky color in transition area to fake SSS
- For normals, blend using ***Reoriented Normal Mapping*** [Barré-Brisebois & Hill 2012]
  - Normals are not colors.
  - You can’t lerp/overlay between directions!
  - Used in game to:
    - Blend the snow detail normal and the macro “wave” snow normal
    - Add detail normal maps everywhere

Stage 3 - Shading (4/)

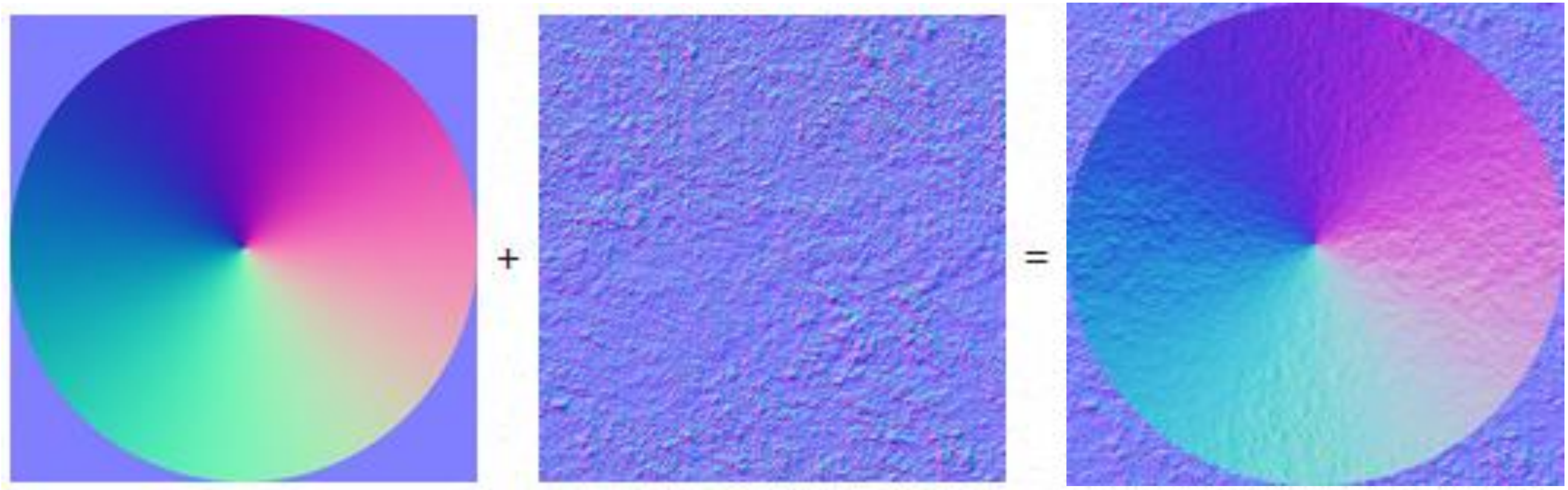


```
float3 t = tex2D(BaseNormal, uv) * float3(2, 2, 2) + float3(-1, -1, 0);
float3 u = tex2D(DetailNormal, uv) * float3(-2, -2, 2) + float3(1, 1, -1);
float3 r = t * dot(t, u) / t.z – u;
```

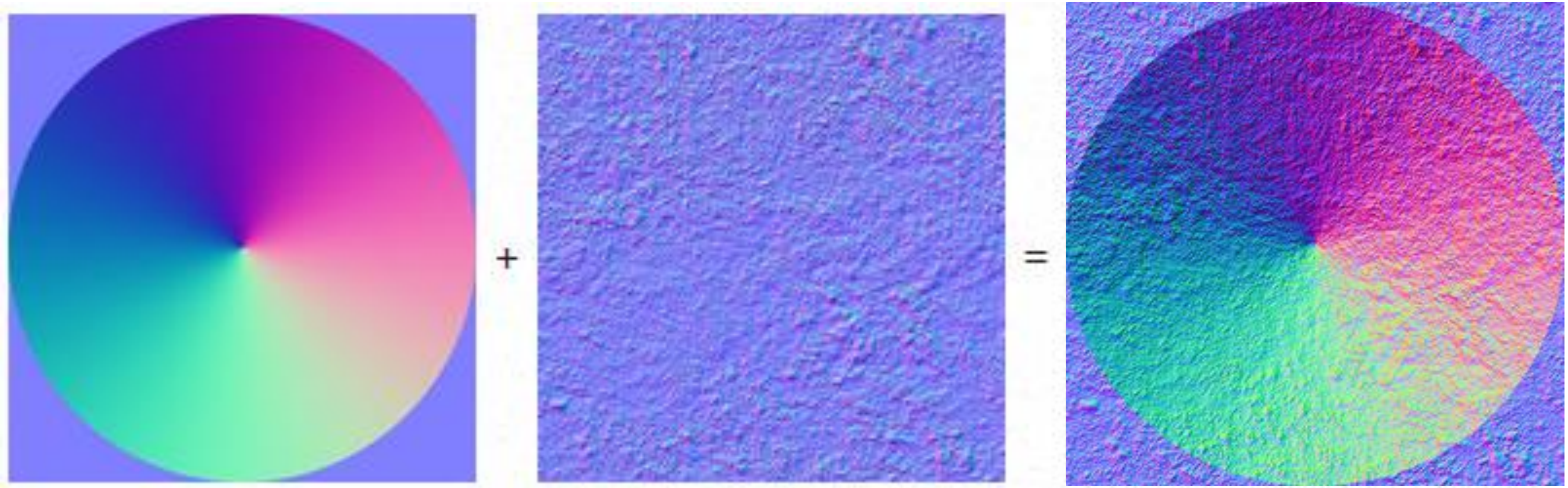
[Barré-Brisebois & Hill 2012]



Linear Interpolation



Overlay



Reoriented Normal Mapping

[Barré-Brisebois & Hill 2012]

Add. Implementation Details (1/)

- **Surface UVs align with ortho frustum**
  - 0-1 range, simplifies heightmap-to-displacement
- **Scaled world-space heightmap res.**
  - Min(512, ¼ * (SurfaceX, SurfaceY))
  - Tries to keep texels “square”
  - Doesn’t need to be high-res, looks better in lower resolutions
  - Must scale *Relief Mapping* parameters

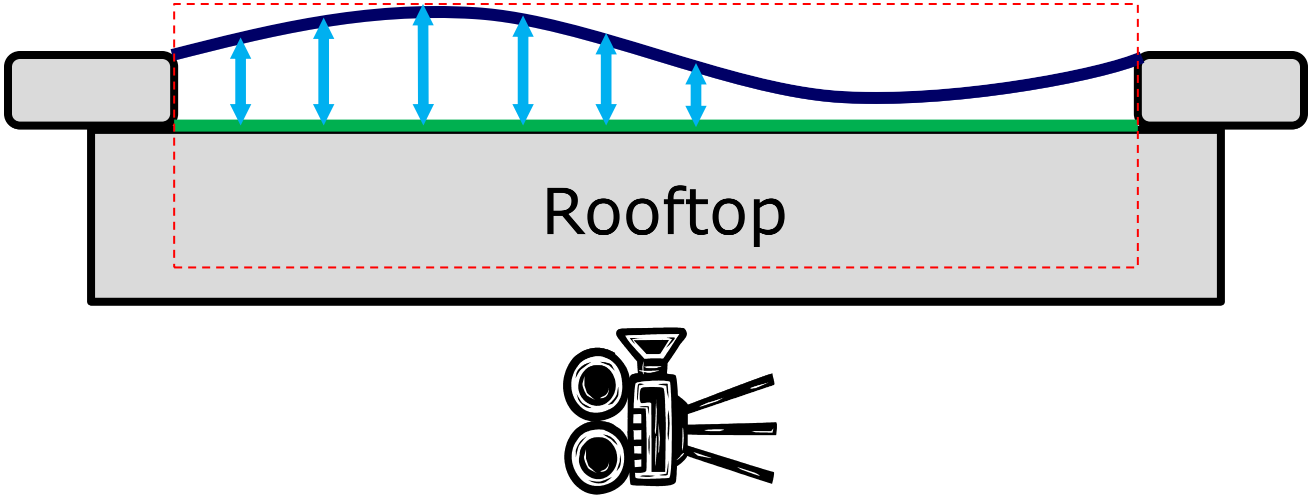
Add. Implementation Details (2/)

- **Split render & tick of active surfaces**
  - Snow surface where Batman stands has priority
  - Only render 2 surfaces/frame (tweakable but good enough, with distance-based priorities)
- **Reuse memory from old heightmaps**
  - Not active/visible (max distance from sphere bounds)
  - Un-streamed open-world zones

DirectX 11 With Tessellation (1/)

- ➢ Feature developed with our friends @ NVIDIA (Evgeny Makarov)
- ➢ Accurate displacement based on depth
  - Capture the height field like a z-buffer
  - Two channels:
    - ○ Minimum height field
    - ○ Projected displacement
  - Allows for additive capture & smoother results.
  - Also allows for deformable snow banks! ☺

DirectX 11 With Tessellation (2/)



⬚ Orthogonal Capture Frustum

🟩 Minimum Height field

🟦 Projected Displacement

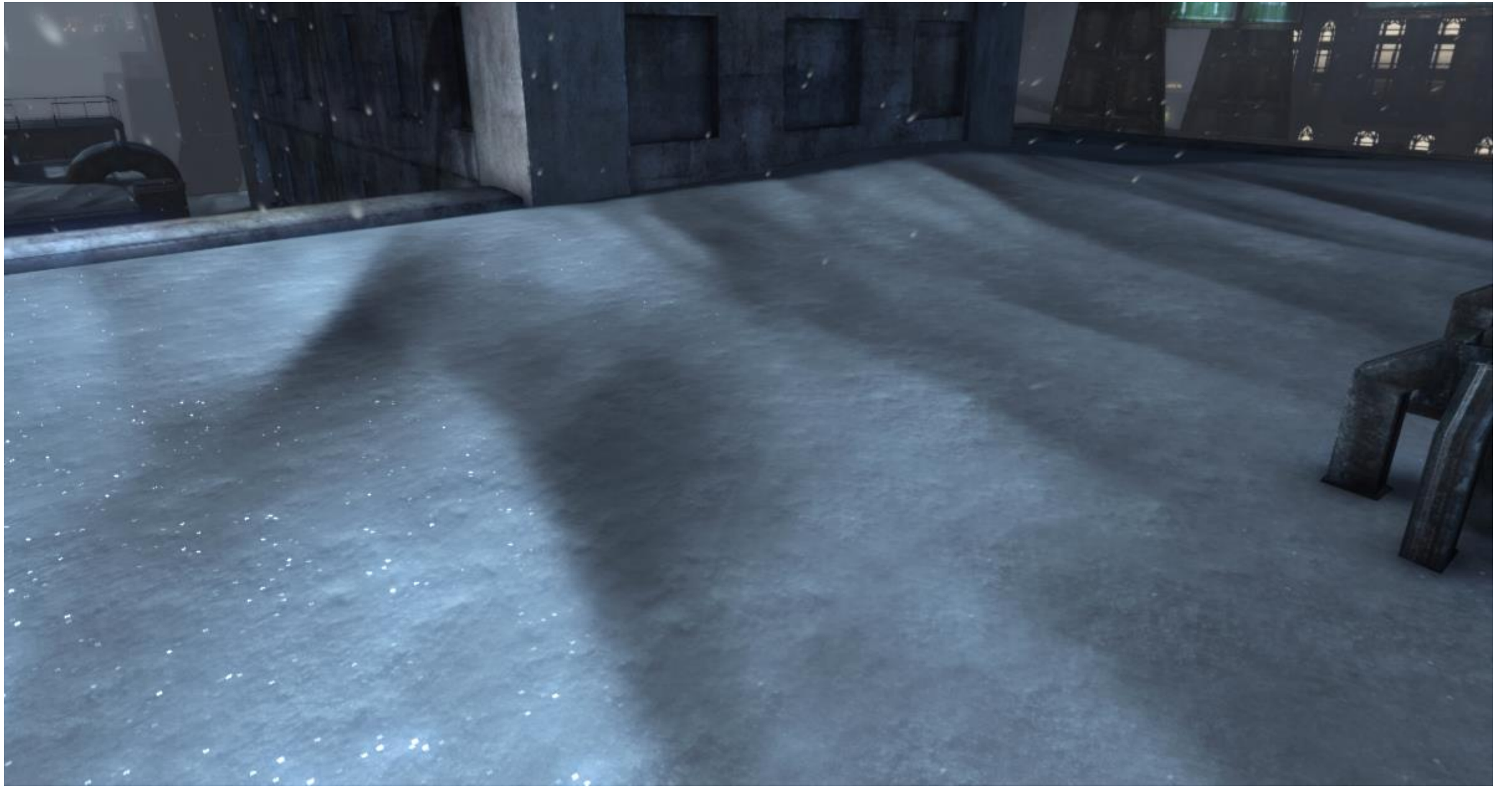
■ Final Surface (displaced)

DirectX 11 With Tessellation (3/)

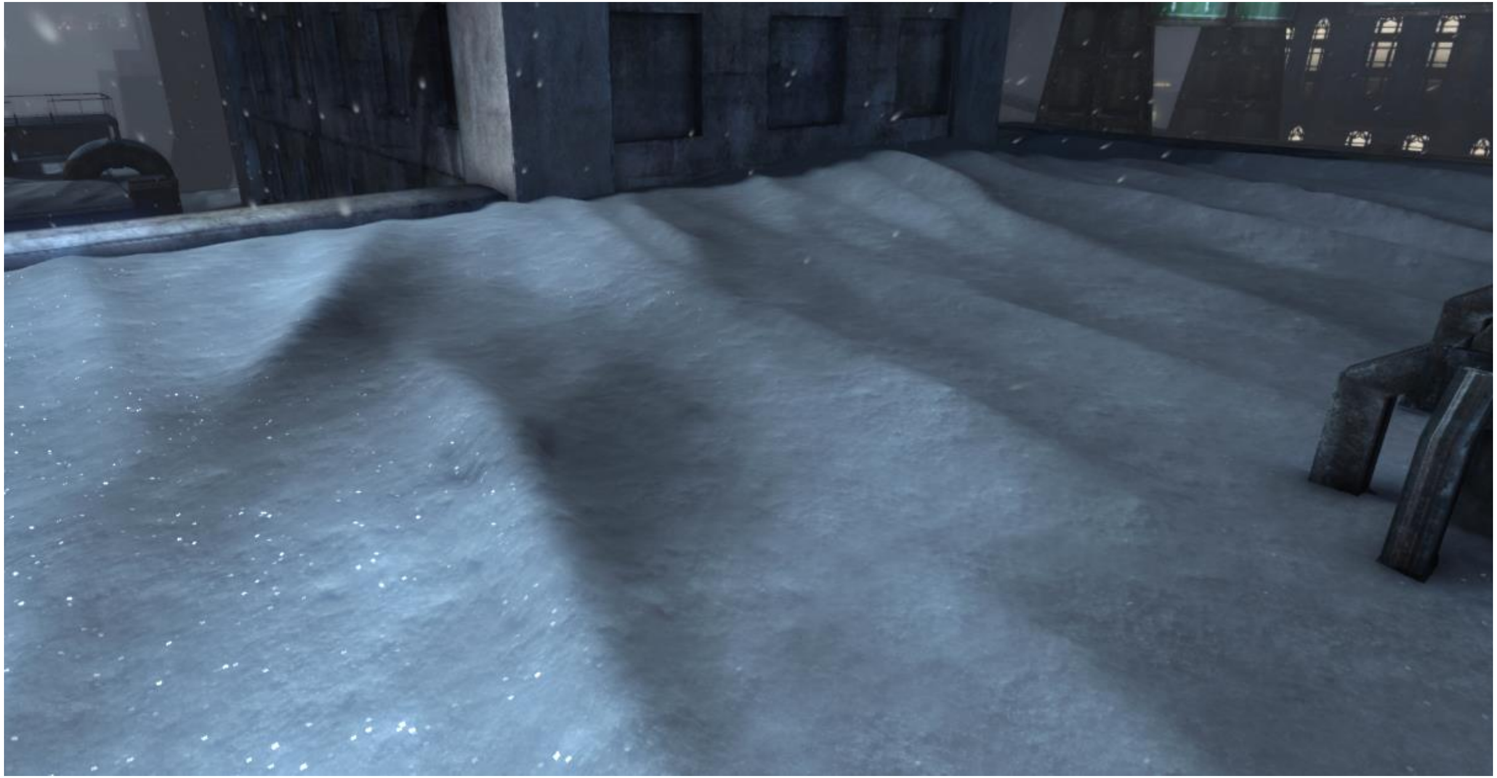
➢ Tessellated version adds detailed displacement calculated from the normal map, globally applied to the snow surface

- Extra detail compared to the relief-mapped version
- Takes the macro normal map to add additional “macro waves”

Without Tessellation (No Macro Deformation)



With Tessellation (Macro Deformation)



DirectX 11 With Tessellation (4/)

- Runtime dicing of snow meshes
- Real geometry means:
  - **Works with Dynamic Shadows**
    - Character shadows now follows the surface and shift with the deformation
    - Self shadowing & self-shading
  - **Works with dynamic ambient occlusion**
    - AO fills-in the trails

DANGER

Performance & Memory

- **Performance**
  - Heightmaps update < 1.0ms GPU on PS3/360
- **Memory**
  - 2 MB (360 / PS3 / WiiU)
    - Since we're using low resolution heightmaps
    - This is flexible, but sufficient for our needs since we allocate/deallocate as the player flies in the world
  - 2-4 MB (FP16 vs FP32 on PC)

Caveats / Issues ?

- **Relief-Mapped Approach**
  - Deformation looks great, but will never be as thick as tessellation. Replace with Parallax Occlusion Mapping?
  - Derive parametric AO from the heightmap?
- **Tessellated Approach**
  - When artists were working on content creation, displacement wasn't taken into account (pre-pass actors, open edges being visible, etc...)
  - Some meshes couldn't use tessellation as there were parts of geometry right under the snow, not supposed to be visible

Future Endeavours…

- Save the heightmaps and reload them?
- Use this technique for other cases, such as sand, mud, etc…

Summary

- A fast and low-memory footprint technique to render deformable snow surfaces
  - Adds a really nice level of interaction between players and the world
  - Depics iconic & organic visuals of deformable snow
- A good tessellation case for your DX11 game using minimal editing and art tweaks

Thank You!

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Questions?

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BATMAN
ARKHAM ORIGINS