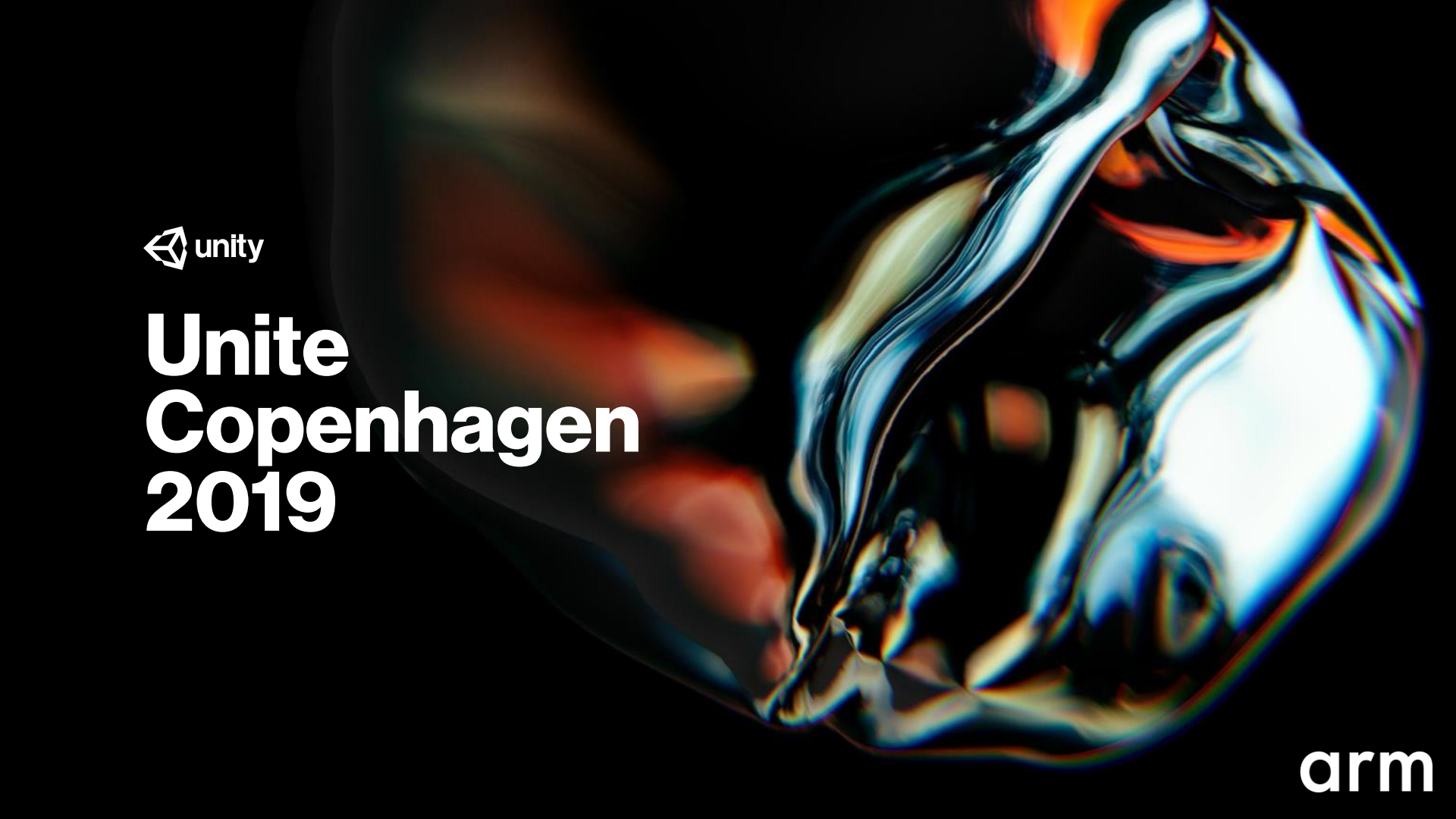

unity
Unite
Copenhagen
2019
arm

How to Improve Visual Rendering Quality in VR

Ryan O'Shea

unity
Unite
Copenhagen
2019

THE MOBILE **GAME** INDUSTRY'S **ARCHITECTURE OF CHOICE**

arm

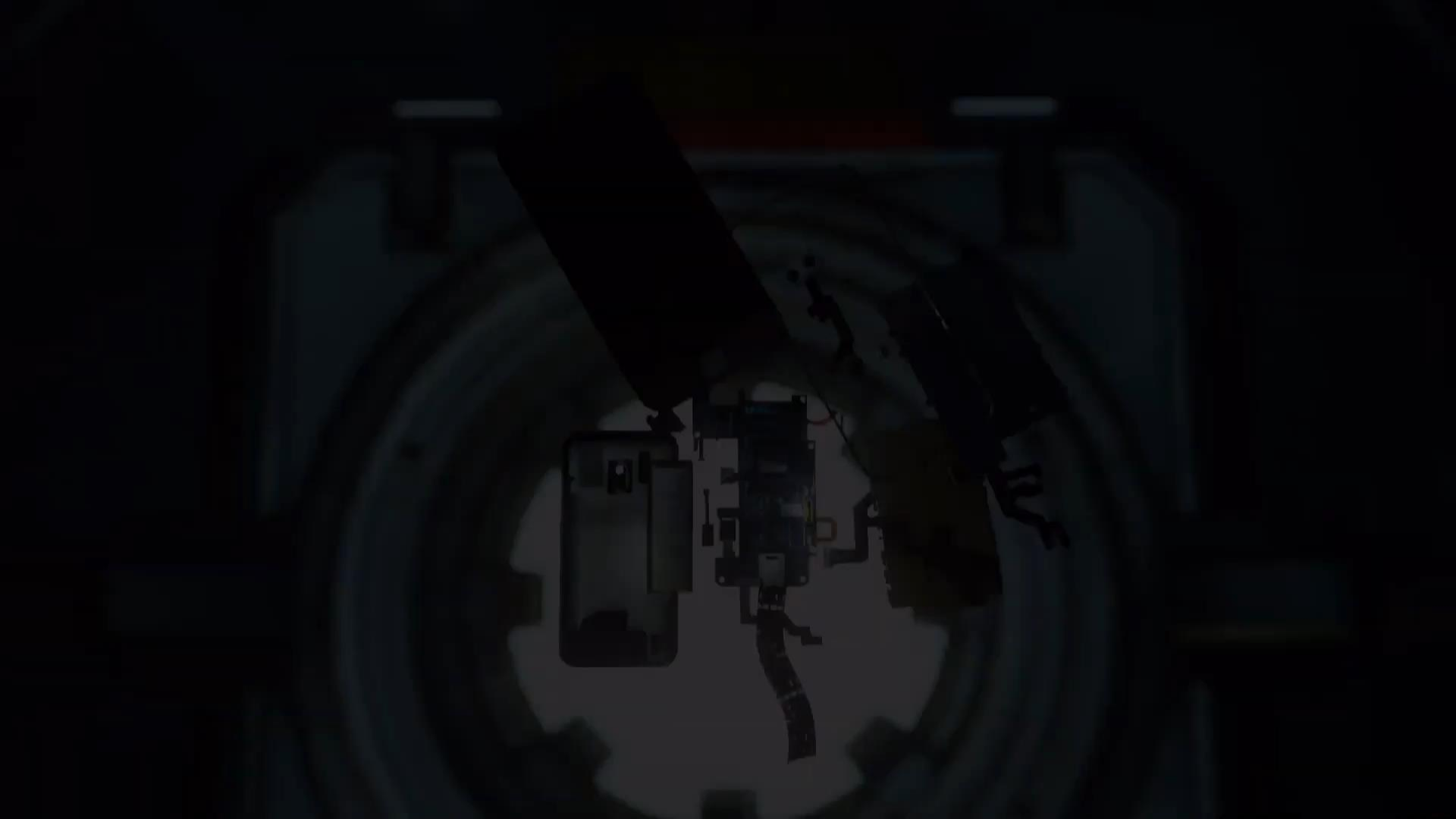
~23 billion Arm Cortex CPUs shipped in 2018

>95% of the world's smartphones are based on Arm

Over 1 billion Arm Mali GPUs shipped last year

1000+ ecosystem partners


arm
arm
arm
2017
1993
Samsung Galaxy S8
Panasonic 3DO



PS4 to Mobile with Inside-out Camera Tracking

arm

Current State of VR

- VR allows developers to deliver new heights of immersion to players
- Yet currently VR, especially on standalone headsets, contains a number of limitations
- These limitations make it an unrealistic, unconvincing and sometimes an uncomfortable experience
- Therefore these limitations must be either solved or mitigated

Standalone VR

2x

Uplift in standalone VR headset install base from previous year

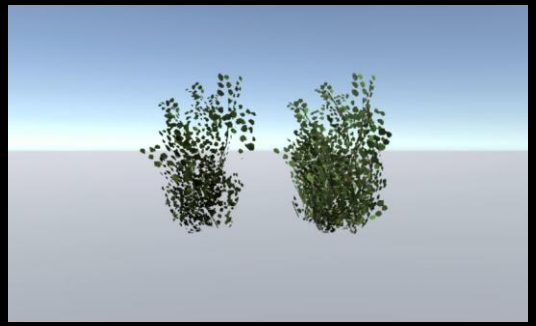
38%

Projected share of total 2019 VR headset sales*

Data from ABI Research report on 360 Video and Virtual Reality Devices and Services 2019

*Excluding mobile VR headsets

Common VR Pitfalls



Aliasing

Banding

Depth

Shadows

arm

Aliasing

- Basics
  - Mipmapping
  - Levels of Details (object and shader)
  - Anti-aliasing
- Texture Filtering
  - Enabling texture filtering for textures is vital to remove aliasing from mapping texels to pixels
- Colour Space
  - Linear colour space can reduce specular aliasing by preventing objects from becoming white as brightness increases
- Alpha Compositing


Alpha Test
Alpha to Coverage

Aliasing – Alpha Compositing

- Alpha test and alpha blend are the two most common methods of alpha compositing in use today
- Despite their popularity, these methods cause large amounts of aliasing or a high performance cost
- Alpha to coverage is a method of alpha compositing that suffers from less aliasing
- Maps the coverage mask from MSAA to the alpha output in order to minimise aliasing
- If the alpha value is 0.5, only half of the coverage samples are rendered to

```
AlphaToMask On
struct frag_in
{
        float4 pos : SV_POSITION;
        float2 uv : TEXCOORD0;
        half3 worldNormal : NORMAL;
};

fixed4 frag(frag_in i, fixed facing : VFACE) : SV_Target
{
        /* Sample diffuse texture */
        fixed4 col = tex2D(_MainTex, i.uv);

        /* Calculate current mip level */
        float2 texture_coord = i.uv * _MainTex_TexelSize.zw;
        float2 dx = ddx(texture_coord);
        float2 dy = ddy(texture_coord);
        float MipLevel = max(0.0, 0.5 * log2(max(dot(dx, dx), dot(dy, dy))));
        col.a *= 1 + max(0, MipLevel) * 0.25;

        /* Sharpen texture alpha to the width of a pixel */
        col.a = (col.a - 0.5) / max(fwidth(col.a), 0.0001) + 0.5;
        clip(col.a - 0.5);

        /* Lighting calculations */
        half3 worldNormal = normalize(i.worldNormal * facing);
        fixed ndotl = saturate(dot(worldNormal, normalize(_WorldSpaceLightPos0.xyz)));
        col.rgb *= ndotl * _LightColor0;

        return col;
}
```

```
AlphaToMask On
struct frag_in
{
        float4 pos : SV_POSITION;
        float2 uv : TEXCOORD0;
        half3 worldNormal : NORMAL;
};

fixed4 frag(frag_in i, fixed facing : VFACE) : SV_Target
{
        /* Sample diffuse texture */
        fixed4 col = tex2D(_MainTex, i.uv);

        /* Sharpen texture alpha to the width of a pixel */
        col.a = (col.a - 0.5) / max(fwidth(col.a), 0.0001) + 0.5;
        clip(col.a - 0.5);

        /* Lighting calculations */
        half3 worldNormal = normalize(i.worldNormal * facing);
        fixed ndotl = saturate(dot(worldNormal, normalize(_WorldSpaceLightPos0.xyz)));
        col.rgb *= ndotl * _LightColor0;

        return col;
}
```

Banding

- Dithering
  - Process of introducing noise to the material in order to disrupt the distinct bands and prevent the undesirable effect
- Tone Mapping
  - A subset of colour grading that transposes HDR colours to fit within the LDR range suitable for displaying on screen, this removes sharp colour gradients

No Post Processing

Dithering & Tone Mapping

Dithering & Tone Mapping (Cropped)

Depth

- Normal Mapping
  - Provides additional details during lighting calculations producing higher detail meshes without additional geometry
  - The illusion is damaged when viewed through stereoscopic lenses
- Parallax Occlusion Mapping
  - An advanced method of normal mapping that accounts for the viewing angle when displacing texture coordinates allowing for a more realistic illusion of depth

Diffuse

Normal

arm

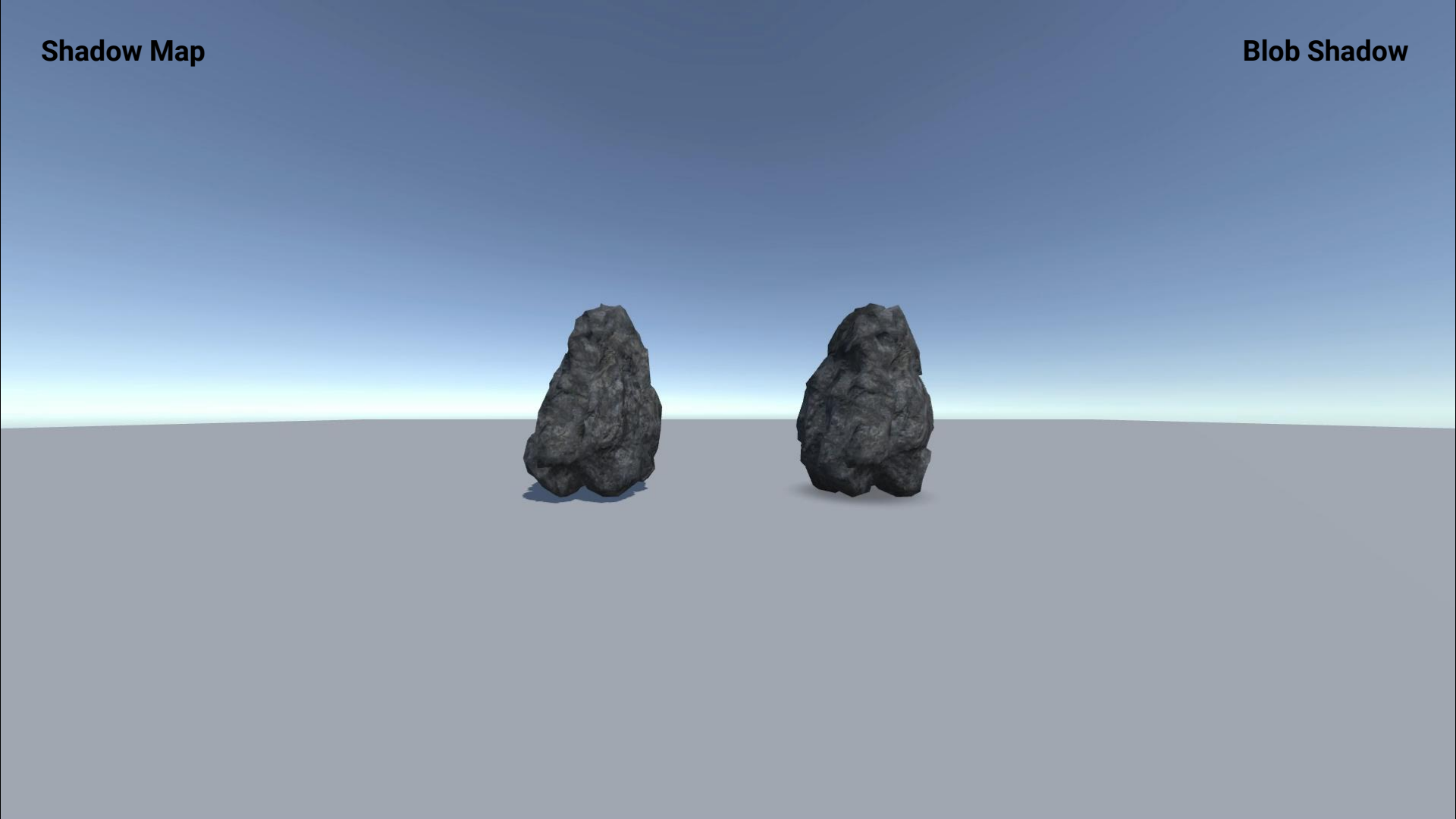
Parallax Occlusion

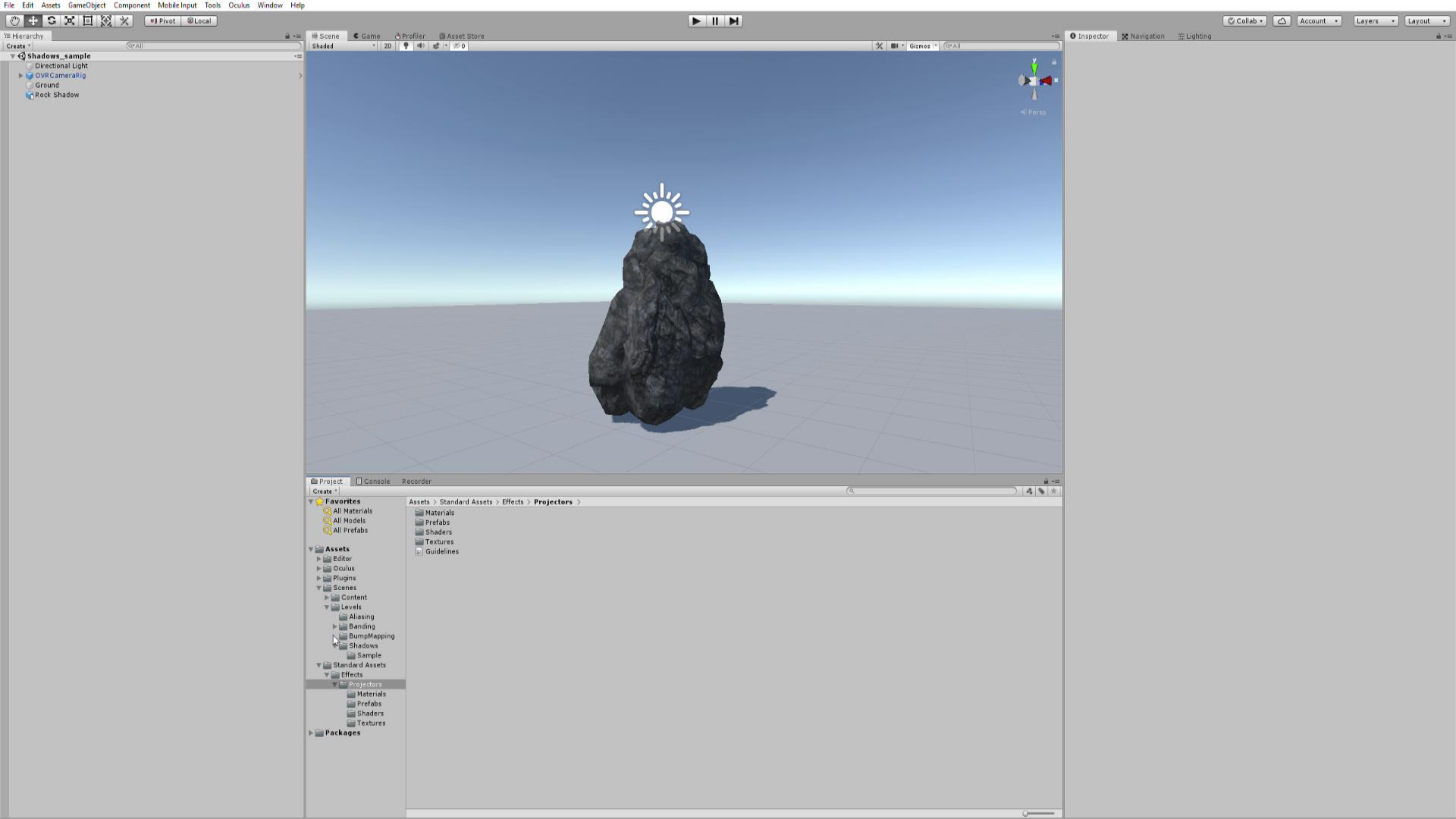
arm

arm

Shadows

- Blob Shadows
  - Shadow mapping techniques which involve rendering accurate shadows produce various artefacts
  - Dynamic blob shadows can be rendered below objects in order to provide fast shadows that do not break immersion
- Baked Shadows
  - Shadow baking doesn’t require any additional render passes, unlike shadow mapping
  - High quality shadows are baked into the textures that they cast shadows upon


Shadow Map
Blob Shadow


File Edit Assets GameObject Component Mobile Input Tools Oculus Window Help
Pivot
Local
Collab
Account
Layers
Layout
Hierarchy
Create
Shadows_sample
Directional Light
OVRCameraRig
Ground
Rock Shadow
Scene
Game
Profiler
Asset Store
Shaded
2D
Gizmos
Persp
Inspector
Navigation
Lighting
Project
Console
Recorder
Favorites
All Materials
All Models
All Prefabs
Assets
Editor
Oculus
Plugins
Scenes
Content
Levels
Aliasing
Banding
BumpMapping
Shadows
Sample
Standard Assets
Effects
Projectors
Materials
Prefabs
Shaders
Textures
Packages
Assets > Standard Assets > Effects > Projectors >
Materials
Prefabs
Shaders
Textures
Guidelines

Conclusions

- There is a wide range of mitigations for aliasing and considerate deployment of all of these is vital
- Banding is difficult to completely remove, so mitigations should be utilised to avoid this pitfall
- Depth simulation is considerably more difficult in VR but parallax occlusion mapping provides a great solution
- Shadows are vital for immersion and blob shadows provide a nice middle ground between quality and impact
- All mitigations work best when combined with level design that is considerate of VR's weaknesses

Resources

- https://bit.ly/2mn7Atw - How to Improve Visual Rendering Quality in VR Guide
- https://community.arm.com/posts/virtual-reality-best-practices-for-mobile - Blog Post
- https://developer.arm.com/unity - Arm Unity Developer Page

arm