Moonlight Blade Rendering Performance Optimization

Xie Weibo Advanced rendering engineer, Tencent mercury studio

> 游戏开发者大会•中国 GAME DEVELOPERS CONFERENCE CHINA SHANGHAI INTERNATIONAL CONVENTION CENTER SHANGHAI, CHINA: OCTOBER 25-27, 2015

ceneRendering			
	CallCount	IncAvg	IncMax
hole Draw Time	1.00		
ait FrameSync	1.00	2.12 ms	0.98 ms
efore Render Time	1.00	0.95 ms	1.33 ms
npulse Render Time	1.00	0.13 ms	0.20 ms
errain List Parse Time	1.00	0.48 ms	0.70 ms
esh List Parse Time	1.00	1.43 ms	2.42 ms
raw Depth Only			0.02 ms
raw Shadow Depth	1.00	0.82 ms	1.12 ms
raw Shadow Combine	0.00	0.00 ms	0.00 ms
raw GBuffer	1.00	4.10 ms	5.90 ms
GBuffer Opaque	1.00	1.98 ms	3.38 ms
GBuffer Terrain	1.00	0.78 ms	1.17 ms
GBuffer SpeedTree	1.00	0.49 ms	
raw Lighting	1.00	5.82 ms	8.25 ms
Draw Translucent	1.00	4.01 ms	
Draw Particle	0.00	0.00 ms	0.00 ms
Draw Water	1.00	3.76 ms	5.22 ms
Water Refelect	1.00	3.62 ms	5.02 ms
WaterRef List Parse	1.00	2.09 ms	2.71 ms
WaterRef Opaque List Parse	1.00	0.52 ms	0.67 ms
WaterRef Terrain List Parse	1.00	0.16 ms	0.21 ms
Draw Opaque Refelect	1.00	1.27 ms	2.12 ms
Draw Terrain Refelect	1.00	0.20 ms	0.30 ms
SourceCurrentDraw Impostor Refelect	1.00	0.02 ms	0.04 ms
peed Tree Cull	1.00	0.50 ms	0.65 ms
raw PostProcess	1.00	0.14 ms	0.51 ms
raw LightShaft Query	1.00	0.01 ms	0.04 ms
raw LocalLigth	1.00	1.21 ms	1.87 ms
uild LocalLigt List	1.00	0.34 ms	0.44 ms
resent Scene	1.00	1.42 ms	1.19 ms
raw UI	1.00	0.57 ms	1.12 ms
etQueryDataTime	0.00	0.00 ms	0.00 ms
enderQueryTime	1.00	0.26 ms	0.38 ms
verlay	1.00	4.41 ms	6.53 ms
ser 1	2.00	0.02 ms	0.02 ms
ser 2	3.00	0.70 ms	0.94 ms
ser 3	0.00	0.00 ms	0.00 ms
ser 4	0.00	0.00 ms	0.00 ms
	0.00	0.00 min	0.00

GPUProfileResult PreRenderLogicWork QSGameRenderGPU ScaleForm QSSceneRenderer_RenderScene RenderImpulse RenderWater RenderImpulse RenderGrass LightViewDepthConstruct OpagueShadow OpaqueShadow OpaqueShadow QSShadowVesturePolicy QSSceneQueryRenderer depthList OcclusionList DepthOnlyPass UIDepth FillParticleTexture GBufferConstruct GBufferHair GBufferOpaque Makeup_Render GBufferImpostor GBufferSpeedTree GBufferTerrain GBufferRoad RenderDecal RenderShadowDecal ScreenSpaceShadowMap DeferrredLighting DirectLighting RenderEmissive LocalLight SkyAndFog TranslucencyRender OSOuterGlowRenderer ResidueEffect Distortion MotionBlurRenderer QSWeatherParticle LightShaft PostFxHDR_Render LensFlare OutlinePass OverHeadTranlucentPass PostFxColor QSUIMapCoverRenderer PostFxAA InterlacedRendering EndDrawUIOnRT QSOverlay Present

Avgl	ime	MaxTime
0.00	ms	0.00 ms
19.2	3 ms	27.30 ms
0.17	ms	1.18 ms
14.4	3 ms	22.05 ms
0.00	ms	0.00 ms
0.01	ms	0.02 ms
0.80	ms	1.70 ms
0.37	ms	0.83 ms
0.11	ms	0.16 ms
0.19	ms	0.70 ms
0.00	ms	0.00 ms
1 76	ms	4 63 ms
0.01	ms	0.02 ms
0.01	me	0.01 ms
0.00	me	0.01 ms
0.21	me	0.29 ms
0.21	ms	0.02 ms
4 20	me	6.40 ms
4.30	ms	0.49 ms
0.01	ms	0.01 ms
3.30	ms	5.13 ms
0.01	ms	0.01 ms
0.14	ms	0.19 ms
0.68	ms	0.92 ms
0.17	ms	0.23 ms
0.00	ms	0.00 ms
0.00	ms	0.00 ms
0.00	ms	0.00 ms
0.49	ms	0.66 ms
4.58	ms	8.15 ms
0.36	ms	0.48 ms
0.03	ms	0.04 ms
1.76	ms	4.39 ms
0.53	ms	0.74 ms
1.89	ms	2.96 ms
0.00	ms	0.00 ms
0.71	ms	0.95 ms
0.00	ms	0.00 ms
0.59	ms	0.79 ms
0.00	ms	0.00 ms
0.00	ms	0.00 ms
0.15	ms	0.73 ms

3.89 ms

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6.33 ms

Performance Analysis Tools

• Stat System

• GPU Profiler 🚤

Stat System



UProfileResult	AvgTime	Ma
RenderLogicWork	0.00 ms	0.0
GameRenderGPU	17.55 ms	24
ScaleForm	0.02 ms	0.0
QSSceneRenderer_RenderScene	13.96 ms	20
RenderImpulse_RenderWater	0.00 ms	0.0
RenderImpulse_RenderGrass	0.01 ms	0.0
LightViewDepthConstruct	1.00 ms	2
OpaqueShadow	0.34 ms	0.9
SpeedTreeShadow	0.00 ms	0.0
Render3dTrees	0.00 ms	0.0
Opaquesnadow	0.16 ms	0.2
SpeedTreeShadow	0.04 ms	0.0
Render3dTrees	0.04 ms	0.0
OpaqueSnadow	0.14 ms	0.4
SpeedTreeSnadow	0.00 ms	0.0
Render3dTrees	0.00 ms	0.0
Of Chadow Vostura Daliev	0.00 ms	0.0
EncodTrooEbadow	0.22 ms	1.7
Dender2dTrees	0.00 mc	1.1
PenderBillhoards	0.00 ms	1.7
OfficencoulonuBandaron	1.69 mc	1.1
dopth list	0.01 mc	
OcclusionList	0.01 ms	0.0
DenthOnlyPace	0.00 ms	0.0
UIDenth	0.24 ms	0.5
OverHeadDenthMack	0.00 ms	0.0
FillDarticleTexture	0.00 ms	0.0
GBufferConstruct	4 54 ms	74
GBufferHair	0.01 ms	0.0
GBufferOpaque	3 38 ms	5.5
GBufferOnaqueInstancing	0.29 ms	0.3
Makeun Render	0.01 ms	0.0
GBufferImpostor	0.16 ms	0.7
GBufferSpeedTree	0.75 ms	1.0
Render3dTree	0.55 ms	0.7
RenderBillboard	0.20 ms	0.2
RenderGrass	0.00 ms	0.0
GBufferTerrain	0.21 ms	0.3
GBufferRoad	0.00 ms	0.0
RenderDecal	0.00 ms	0.0
RenderShadowDecal	0.02 ms	0.1
ScreenSpaceShadowMap	0.54 ms	0.7
DeferrredLighting	4.25 ms	6.7
DirectLighting	0.39 ms	0.5
SkinLighting	0.09 ms	0.1
RenderEmissive	0.10 ms	0.5
LocalLight	1.16 ms	2.7
SkyAndFog	0.57 ms	0.8
TranslucencyRender	2.02 ms	2.8
RenderWaterAndTranslucency	2.02 ms	2.8
TransBeforeWater	0.00 ms	0.0
RestoreRefraction	0.26 ms	0.3
RenderWaterSelf	0.01 ms	0.0
RenderWaterSelf	0.00 ms	0.0
WaterRenderRef	1.65 ms	2.2
RenderWaterSelf	0.02 ms	0.0
KenderwaterSeit	0.00 ms	0.0
OCOuter Claur Bandaran	0.07 ms	0.1
DesidueEffect	0.00 ms	0.0
Distortion	0.00 ms	0.0
MotionBlurDenderer	0.00 ms	0.0
OSWeatherParticle	0.00 ms	0.0
LightShaft	0.00 ms	0.0
PostExHDR Render	0.74 ms	1.0
LensFlare	0.00 ms	0.0
OutlinePass	0.00 ms	0.0
OverHeadTranlucentPass	0.00 ms	0.0
PostFxColor	0.00 ms	0.0
OSUIMapCoverRenderer	0.00 ms	0.0
PostFxAA	0.63 ms	0.8
InterlacedRendering	0.00 ms	0.0
EndDrawUIOnRT	0.00 ms	0.0
QSOverlay	0.04 ms	0.0
Present	2.88 ms	4.7

GPU Profiler

Real-time statistics of each game module's

GPU overhead

Lightweight, has little impact on the game

performance

In-built Profiler, independent of third parties

Other projects can also use it easily

UE3 – FarCry has not this feature

Shader instruction optimization case



Point light rendering



Point light optimization



Water reflection optimization

	PUProfileResult	AvgTime	MaxTime	活力 150/150 背包 15/40 11 0 35 0		ALCONTRACTOR	₩ ₩ ₩ ₩ ₩ ₩ ₩ 06:04:37 ₩	
Name Note	reRenderLogicWork	0.00 ms	0.00 ms	7765		ST. AND		1 1
	SGameRenderGPU	8.47 ms	14.49 ms	7			杭州 · 落云滩	
	QSSceneRenderer_RenderScene RenderImpulse	5./6 ms	8.05 ms			No. of Concession		d'
	RenderNodes	0.00 ms	0.00 ms	The second second			1433,2141	files of a
	RenderImpulse	0.01 ms	0.01 ms				and the second	
	RenderNodes	0.00 ms	0.00 ms		AD THERE ARE STOLEN		the state where the second sec	
	OpaqueShadow	0.30 ms	0.40 ms					0
	SpeedTreeShadow	0.23 ms	0.30 ms					
	OpaqueShadow	0.62 ms	1.35 ms					
	OpaqueShadow	0.51 ms	1.21 ms 0.22 ms					
	SpeedTreeShadow	0.09 ms	0.12 ms	MERCENT AND				
	QSShadowVestureMultiFramePolicy	0.00 ms	0.00 ms	AND DESCRIPTION TO THE REAL OF A DESCRIPTION OF A DESCRIP				
	SpeedTreeShadow OSSceneQueryPenderer	0.00 ms	0.00 ms			CAL PRINTERSON		
Auto Auto Auto Auto Auto Auto Auto Auto	depthList	0.00 ms	0.00 ms	The second s	S DALLA MANALINA MANA			C. Contra
	OcclusionList	0.00 ms	0.00 ms	THE REAL PROPERTY AND A REAL PROPERTY A REAL PROPE		and the state of the	the second states	Sector 1
current curre	DepthOnlyPass	0.03 ms	0.03 ms	A Read and Some And a second second		- All All All		Carlos and
Calific Construct 217 170 Calific Construct 170 150 Calific Construct 170	CalcExposureScale	0.00 ms	0.00 ms	Autor and a second s	and the state of the	A State of the state of the		
Interfactor 0.00 0.00 0.00 Interfactor 0.00	GBufferConstruct	2.12 ms	3.28 ms		The second s	h and the start		122
1 <td>GBufferHair</td> <td>0.00 ms</td> <td>0.00 ms</td> <td></td> <td></td> <td></td> <td></td> <td>6.5</td>	GBufferHair	0.00 ms	0.00 ms					6.5
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Bit of the	GBufferRoad	0.00 ms	0.00 ms			AND AND AND		1 and
Sincerelization 0.00 min <t< td=""><td>RenderDecal</td><td>0.00 ms</td><td>0.00 ms</td><td></td><td></td><td>Charles IN</td><td>第十四回: 飞流翻浪现连环</td><td> F2</td></t<>	RenderDecal	0.00 ms	0.00 ms			Charles IN	第十四回: 飞流翻浪现连环	F2
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Image: State in the state	DeferrredLighting	0.53 ms	0.72 ms				消灭翻浪坞外围水匪	
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OverHead IranucenPass 0.01 ms 0.01 ms PostFxAA 0.00 ms 0.00 ms EdgeDetect 0.17 ms 0.23 ms BlendWeight 0.22 ms 0.29 ms ScaleForm 0.00 ms 0.00 ms C9SOverlay 0.00 ms 0.00 ms Present 1.77 ms 5.54 ms	OutlinePass	0.00 ms	0.00 ms	and the second s		T V LIMR		
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PostrAA 0.65 ms 0.87 ms Edgebet 10.22 ms 0.29 ms NeightborBlend 0.26 ms 0.35 ms Scaleform 0.00 ms 0.00 ms InterlacedRendering 0.00 ms 0.00 ms Scaleform 0.25 ms 0.63 ms Present 0.35 ms 0.64 ms V 0.33 ms 0.44 ms V 0.44 ms 0.55 ms Present 1.77 ms 5.54 ms V 0.33 ms 0.44 ms V 0.34 ms 0.44 ms V 0.44 ms 0.64 ms V 0.44 ms 0.64 ms V 0.44 ms 0.64 ms V 0.44 ms 0.7 ms 0.54 ms 0.64 ms 0.64 ms 0.10 ms 0.64 ms <td>QSUIMapCoverRenderer</td> <td>0.00 ms</td> <td>0.00 ms</td> <td></td> <td></td> <td></td> <td></td> <td></td>	QSUIMapCoverRenderer	0.00 ms	0.00 ms					
EdgeDetect 0.17 ms 0.23 ms BlendWeight 0.26 ms 0.35 ms InterlacedRendering 0.00 ms ScaleForm 0.26 ms 0.63 ms RenderUIBillBoardRT 0.25 ms 0.63 ms OSOverlay 0.03 ms 0.04 ms Present 1.77 ms 5.54 ms	PostFxAA	0.65 ms	0.87 ms	Protection and the second states and the second states				
belndweight Neightborblend InterfacedRendering ScaleForm RenderUIBillBoardRT 0.25 ms 0.63 ms 0.63 ms 0.65 ms 0.55 ms 0.63 ms 0.65 ms 0.63 ms 0.65 ms 0	EdgeDetect 无法王弃、请将其施放到快	0.17 ms	0.23 ms	The second of th				
InterlacedRendering 0.00 ms 0.00 ms 0.00 ms 0.00 ms 0.63 ms 0.64 ms 0	NeightborBlend	0.22 ms	0.29 ms	CARL THE CAR				
ScaleForm 0.26 ms 0.63 ms RenderUIBillBoardRT 0.25 ms 0.04 ms OSOverlay 0.03 ms 0.04 ms Present 1.77 ms 5.54 ms → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → → <td>InterlacedRendering</td> <td>0.00 ms</td> <td>0.00 ms</td> <td></td> <td></td> <td></td> <td>÷ X</td> <td>A</td>	InterlacedRendering	0.00 ms	0.00 ms				÷ X	A
RenderUlBulBoardR1 0.25 ms 0.03 ms QSOverlay 0.03 ms 0.04 ms Present 1.77 ms 5.54 ms ⇒ ⇒ ⇒ G038/6088 ⇒ G14/614 ↓ <td>ScaleForm</td> <td>0.26 ms</td> <td>0.63 ms</td> <td></td> <td></td> <td></td> <td></td> <td></td>	ScaleForm	0.26 ms	0.63 ms					
Present → ==== → = → = → → → → → → → → → → → →	OSOverlay	0.25 ms	0.63 ms	A State of the second	A	and the second		à
	Present	1.77 ms	5.54 ms	qs7777		States and		
		and a second second		6088/6088	614/614	and the second		
		1000	and the second		4145/4145	Contraction of the second		
	The particular and the	5 000	and the			8 9 0 0		

Local Reflection



Quarter Buffer rendering of transparent objects

- Large-scale particle pixel filling is a big bottleneck
- Many particles mainly contain low frequency information

Quarter Buffer causes significant aliasing

Full Resolution

Quarter Resolution

Bilateral Filter



Quarter Buffer Performance Data

VolumeCloud	QuarterDepth	Particles	UpSample	Total	
¼Buffer off	0.0ms	2.5ms	0.0ms	2.5ms	E AM
¼Buffer on	0.05ms	0.8ms	0.15ms	1.0ms	

Save 1.5ms!!!>

Memory Optimization

A	В	С	D	E	F
TextureName	TexMem	Width	Height	MipLevels	Format
.\Data\Scene\Texture\MipMapChain.dds	2796344	2048	2048	12	DXT1
Bone	786432	384	128	1	A32B32G32R32F
Bone	786432	384	128	1	A32B32G32R32F
Bone	786432	384	128	1	A32B32G32R32F
.\Data\Scene\Texture\water_rui_007_a.dds	349680	512	512	10	DXT5
data\Effects\WetNormal.dds	131200	512	512	1	DXT1
data\Effects\LightningMask.dds	131200	512	512	1	DXT1
.\Data\Scene\Texture\Distortion02.dds	131200	512	512	1	DXT1
Data\Scene\skybox\moon.dds	65664	256	256	1	DXT5
data\engine\AreaMap33.dds	54578	165	165	1	PF_A8L8
.\Data\Scene\Texture\shadow01.dds	22000	128	128	8	DXT5
.\Data\Scene\Texture\random.bmp	17464	128	128	1	G8
.\Data\Scene\Texture\Caustics 0.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_1.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_2.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_3.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_4.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_5.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_6.dds	11064	128	128	8	DXT1
.\Data\Scene\Texture\Caustics_7.dds	11064	128	128	8	DXT1

RenderTarget allocation

- Use Pool to allocate
 - Share RenderTarget
 - Manage RenderTarget lifecycle
 - Track RenderTarget allocation by name
 - GC

7e3 Buffer With pre-exposed color/ • A2 • Th of 0.0 20MB VM Saved

Visibility Optimization

- Use Tag Visibility Test to greatly improve the efficiency of Visibility Test (by nearly 4 times)
- Use Tag's Software Occlusion Culling, to clip invisible objects according to terrain, and greatly improve the performance
- Integrate the bounding box function within object to greatly improve the performance of home city
- Speed Tree uses Tag Occlusion Culling to improve the performance

Occlusion Debug View



Test results of Jiuhua area without Occlusion



Test results of Jiuhua area with Occlusion



Jiuhua Occlusion Culling Debug View



Jiuhua data comparison

Test Conditions	Culling Total	Terrain	List Parse	Mesh Par	Mesh List Parse		uffer	Total CP		C	PU Saved
Occlusion Culling off	0.29ms	0.0	58ms	0.26	ms	2.35ms		16.10ms			0
Occlusion Culling on	0.76ms	0.2	24ms	0.05ms		0.99ms		14.53ms			1.57ms
Test Conditions	Triangles Total	Trian Terra	gles ain S	Triangles Static Mesl	Tr h Spo	riangles eed Tree	Trian Sav	ngles /ed	GPU T	otal	GPU Saved
Occlusion Culling off	1132884	1290)40	438958	5	518486		0 10.7		ms	0
Occlusion Culling on	515151	719	68	193032	2	203795	617	733	9.2n	ns	1.51ms
Test Conditions	DP Total		DP Ter	rain	DP Sta	atic Mesh	DP	Speed	Tree	DF	Saved
Occlusion Culling off	1198		430)	3	341		105			0
Occlusion Culling on	608		123 88 83		88				590		

Test results of Hangzhou home city without Occlusion Culling



Test results of Hangzhou home city with Occlusion Culling



Hangzhou home city Occlusion Culling Debug View



Hangzhou home city data comparison

Test Conditions	Culling Total	Terrain List Parso	e Mesh I Parse	Mesh List Dr Parse		GBuffer	Total C	PU	CPU Saved
Occlusion Culling off	0.51ms	0.61ms	0.78m	0.78ms		3ms	21.91	ms	0
Occlusion Culling on	1.35ms	0.03ms	0.10m	0.10ms		9ms	16.50	ms	5.41ms
Test Conditions	Triangles Total	Triangles Terrain	Triangles Static Mesh	Tria Spee	ngles d Tree	Triangles Saved	GPU	Total	GPU Saved
Occlusion Culling off	1546871	102128	952971	239	9556	0	13.9	2ms	0
Occlusion Culling on	408263	33536	259931	9931 41463		1138608	9.8	3ms	4.09ms
Test Conditions	DP Total	DP Terrain	DP Sta	tic Me	sh	DP Speed Tre		D	P Saved
Occlusion Culling off	2225	417	8	832		77			0
Occlusion Culling on	764	23	23 192 43		43			1461	

Visibility Optimization

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Test Conditions	Culling Total	Terrain	List Parse	Mesh Par	Mesh List Parse		uffer	Total CP		C	PU Saved
Occlusion Culling off	0.29ms	0.0	58ms	0.26	ms	2.35ms		16.10ms			0
Occlusion Culling on	0.76ms	0.2	24ms	0.05ms		0.99ms		14.53ms			1.57ms
Test Conditions	Triangles Total	Trian Terra	gles ain S	Triangles Static Mesl	Tr h Spo	riangles eed Tree	Trian Sav	ngles /ed	GPU T	otal	GPU Saved
Occlusion Culling off	1132884	1290)40	438958	5	518486		0 10.7		ms	0
Occlusion Culling on	515151	719	68	193032	2	203795	617	733	9.2n	ns	1.51ms
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Occlusion Culling off	0.51ms	0.61ms	0.78m	0.78ms		3ms	21.91	ms	0
Occlusion Culling on	1.35ms	0.03ms	0.10m	0.10ms		9ms	16.50	ms	5.41ms
Test Conditions	Triangles Total	Triangles Terrain	Triangles Static Mesh	Tria Spee	ngles d Tree	Triangles Saved	GPU	Total	GPU Saved
Occlusion Culling off	1546871	102128	952971	239	9556	0	13.9	2ms	0
Occlusion Culling on	408263	33536	259931	9931 41463		1138608	9.8	3ms	4.09ms
Test Conditions	DP Total	DP Terrain	DP Sta	tic Me	sh	DP Speed Tre		D	P Saved
Occlusion Culling off	2225	417	8	832		77			0
Occlusion Culling on	764	23	-	192		43			1461
Vegetation

- Improve Billboard details
- Integration of Billboard and land surface
- FarTree
- Vegetation mirror
- Optimization methods

Improve Billboard details



Integration of Billboard and land surface



FarTree



Vegetation mirror



Vegetation performance optimization

- Shadow Optimization
- CPU Optimization
- Data Optimization
- Occlusion Culling
- Memory Optimization

Shadow Optimization



CPU Optimization

- FreeAlloc and quick allocation releasing tree nodes significantly improved the fluency
- Cache BuildInstanBuffer time has been optimized and shorten from 7-8ms to 0.5ms
- Enabled compiler SSE optimization

Vegetation Resource Optimization





Data Optimization



Occlusion Culling



Memory Optimization

Used DefaultPool to allocate mapping and reduce memory usage

usuge	ALC I A A A A A A A A A A A A A A A A A A	MemosedAvg	riemusedmax	% of lotal	
0	Memory Texture	38.17 MB	38.17 MB	0.00% [0 Bytes]	
Too mu	Memory Alloctor	30.88 MB	30.88 MB	0.00% [0 Bytes]-+	
• 100 mu	Jemory Vertex	104.12 MB	104.12 MB	0.00% [0 Bytes DLEU	Ø
	Memory Index	1.52 MB	1.52 MB	0.00% [0 Bytes]	
IOT OT M	ETHORY				
	otat	MemUsedAvg	MemUsedMax	% of Total	
	Memory Texture	37.82 MB	37.82 MB	0.00% [0 Bytes]	
	Memory Alloctor	30.09 MB	30.09 MB	0.00% [0 Bytes]	
	Memory Vertex	11.45 MB	11.45 MB	0.00% [0 Bytes]	
	Memory Index	1.76 MB	1.76 MB	0.00% [0 Bytes]	

FarTree Performance

GPU performance without FarTree

GBufferConstruct	10.37 ms
GBufferHair 🗸	0.01 ms
GBufferOpaque	4.17 ms
GBufferSpeedTree	1.44 ms
GBufferTerrain	4.65 ms
GBufferRoad	0.01 ms
RenderDecal	0.01 ms
RenderShadowDecal	0.00 ms

- GPU overhead increased 0.5ms
- CPU overhead increased 0.5-1ms
- The number of trees increased from 2-3000 to 50-90k, significantly increasing the scene content

GPU performance with FarTree

OverneauDepthmask	0.00 ms
GBufferConstruct	10.82 ms
GBufferHair	0.01 ms
GBufferOpaque	4.08 ms
GBufferSpeedTree	3.05 ms
GBufferTerrain	3.58 ms
GBufferRoad	0.01 ms
RenderDecal	0.01 ms
RenderShadowDecal	0.00 ms
ScreenSpaceShadowMap	2.15 ms
Least in batche dawn	0.00

Low and medium configuration optimization

- Tree replacement re
- Halved the texture s mapping by 4 times
- Reduced the number
- Decreased the show



Final results of far vegetation



Flowers



Wheat field SpeedTreeDetail



Grass Rough Cullir Grass SetInstance Grass SetExtent Grass UpdateInsta GC Time CalcExtent SplitCell Grass Mem Memory Texture Memory Alloctor Memory Vertex



Memory VertexShader Grass Num Triangles Draw Drwa Primitive Num Tree Total Num Grass Total Num Tree/Grass Instance Num Vest Cell Num Vest Triangles Num

UpdateInstanceBuffer JpdateBillboardInsta AppendInstance reeSetExtent reeSetInstance

BuildCellInstance llocTreeNode reeTreeNode

	1.00	0.77 ms	1.17 ms
	5.00	1.67 ms 🖌	2.81 ms
ceBuffer	0.00	0.00 ms	0.00 ms
	0.00	0.00 ms	0.00 ms
	1.00	0.07 ms	0.14 ms
	1.00	0.00 ms	0.00 ms
		0.11 ms	0.18 ms
	0.00	0.00 ms	0.00 ms
- Aller		0.00 ms	0.00 ms
	0.00	0.00 ms	0.00 ms
GBufferConstruct		7.76 ms	10.47 ms
GBufferHair		0.00 ms	0.00 ms
GBufferOpaque		0.66 ms	1.18 ms
GBufferOpaqueIns	stancing	0.18 ms	0.54 ms
Makeup_Render		0.00 ms 🌙	0.00 ms
GBufferImpostor		0.03 ms 🥖	0.05 ms
GBufferSpeedTree		6.52 ms	8.89 ms
Render3dTree		6.28 ms	8.58 ms
RenderBillboard		0.22 ms	0.30 ms
RenderGrass		0.02 ms	0.03 ms
GBufferTerrain		0.51 ms	0.83 ms
GBufferRoad		0.02 ms	0.11 ms Byte
RenderDecal		0.00 ms	0.00 ms Byte
RenderShadowDecal		0.00 ms	0.01 ms Byte
ScreenSnaceShadowMa	in	0.65 ms	0.90 ms Byte
N.L. 28600 MORA	879.00 KB	879.00 KB	0.00% [0 Byte
	1.58 MB	1.58 MB	0.00% [0 Byte
	0.00 Bytes	0.00 Bytes	0.00% [0 Byte
	0.00 Bytes	0.00 Bytes	0.00% [0 Byte
	Average		A REARDING PLANE
The second second second second	4.00	State and State of State	A A A A A A A A A A A A A A A A A A A
			AND

829817.00 110.00 22409.00 460.00 59150.00 0.00

0.00

- Andrew	
操行	

Impostor Rendering



Basic ideas

- Offline Texture Generate
- Same objects share the same texture
- Instance finished at one time, and every object is a patch

Moonlight Blade requirements

- Not need to load the entity of small objects
- Fully automatic Cook Impostor Texture
- Offline Impostor taking over the rendering of all small objects
- Use one DP to draw all small objects

Impostor Practice



Home city performance test

- Entity number
- Memory
- CPU time
- GPU time
- Graphics card load
- Culling
- Reflection

Entity number

Decreased from 2206 to 1971

wFanel	B Search	🗙 📃 Simple View
NewList	Show Hide	
stat render runti engi	Property	Value
Show	▲QSEngineConfig	
GeRuntimeConfig	RenderUI	V True
GeRuntimeStatistic	ShowAndSaveDefaultLevelConfig	False
QS3DUIRenderConfig	▲BaseConfig	1
QSEngineConfig	GCFreq	1
QSRenderConfigMgr	StreamingEntitySize	15.00000
QSRenderStatistics	ForceStreamingTime	0.50000
QSStatMgr	ForceStreamingEntityRadius	10.00000
RenderEventMgr	SmallEntityRadius	500.00000
	MiddleEntityRadius	1000.00000
	LargeEntityRadius	2500.00000
	HugeEntityRadius	6400.00000
	SmallEntityMagicValue	0.02000
	MiddleEntityMagicValue	0.01000
	LargeEntityMagicValue	0.01000
	HugeEntityMagicValue	0.04000
	NumEntityLoaded	1971
	FPSLimit	60.00000
	FrameTimeLimit	0.20000
	LevelLoadSectorRange	15
	Levell oadEntityBange	6

CPU time

- MeshListParse saved 0.36ms
- Gbuffer saved 0.65ms

Mesh List Parse Time	1.00	1.04 ms	1.56 ms
GBuffer Opaque	1.00	1.63 ms	2.70 ms
GBuffer Terrain	1.00	0.53 ms	0.88 ms
GBuffer SpeedTree	1.00	0.40 ms	0.59 ms

Mesh List Parse Time	1.00	1.40 ms	1.92 ms
GBuffer Opaque	1.00	2.28 ms	3.02 ms
GBuffer Terrain	1.00	0.51 ms	0.69 ms
GBuffer SpeedTree	1.00	0.38 ms	0.46 ms

GPU time

GBufferOpaqu^{GBufferConstruction} GBufferHair

Dufferconstruct	0.30 ms	5.01 ms
GBufferHair	0.00 ms	0.00 ms
GBufferOpaque	5.22 ms	7.57 ms
GBufferOpaqueInstancing	0.40 ms	0.54 ms
Makeup_Render	0.01 ms	0.01 ms
GBufferImpostor	0.00 ms	0.00 ms
GBufferSpeedTree	0.82 ms	1.10 ms
GBufferTerrain	0.25 ms	0.33 ms
GBufferRoad	0.00 ms	0.00 ms
RenderDecal	0.00 ms	0.00 ms
RenderShadowDecal	0.00 ms	0.00 ms
GBufferConstruct	4.96 ms	7.22 ms
GBufferHair	0.00 ms	0.00 ms
GBufferOpaque	3.77 ms	5.63 ms
GBufferOpaqueInstancing	0.41 ms	1.07 ms
Makeup_Render	0.01 ms	0.01 ms
GBufferImpostor	0.15 ms	0.22 ms
GBufferSpeedTree	0.81 ms	1.46 ms
GBufferTerrain	0.21 ms	0.29 ms
GBufferRoad	0.00 ms	0.00 ms
RenderDecal	0.00 ms	0.00 ms
RenderShadowDecal	0.00 ms	0.02 ms

Graphics card load

Triangles Terrain	76080.00
Triangles Ocean	0.00
Triangles StatiMesh	1723201.00
Triangles SkinMesh	112347.00
Triangles Water	6.00
Triangles Particle	0.00
Triangles SpeedTree	97660.00
Realtime Impostor Num	0.00
Offline Impostor Num	4180.00
DP Terrain	351.00
DP Ocean	0.00
DP StaticMesh	791.00

Triangles Terrain	69496.00
Triangles Ocean	0.00
Triangles StatiMesh	2207019.00
Triangles SkinMesh	104923.00
Triangles Water	6.00
Triangles Particle	0.00
Triangles SpeedTree	99180.00
Realtime Impostor Num	0.00
Offline Impostor Num	0.00
DP Terrain	335.00
DP Ocean	0.00
DP StaticMesh	1050.00

Culling

- Impostor adding additional visibility needs 1ms
- Not Load far entity
- Raster Obb time reduced from 2ms to 0.5ms!!!
- Basically the same

Reflection

• CPU time saved 0 35ms

•	GPU	time	save
			water

$\Delta u \sim d \cap$	TranslucencyRender	2.98 ms	4.74 ms	
aveu u	ORAdueEffect	0.00 ms	0.00 ms	
	RenderWaterAndTranslucency	2.98 ms	4.74 ms	
Katan Osfaller	UpdateWave	0.00 ms	0.01 ms	4.25 m
aveu u	.4 Moset	0.07 ms	0.09 ms	4.23 m
WaterRef Li	RestoreRefraction	0.38 ms	0.51 ms	0.78 m
WaterKei U	RenderWaterSelf	0.00 ms	0.00 ms	0.70 m
waterker re	RenderWaterSelf	0.00 ms	0.00 ms	0.52 m
Draw Opaqu	Se WaterRenderRef via ga com/	2.48 ms	4.07 ms	1.49 m
Draw Terrai	RenderWaterSelf	0.02 ms	0.03 ms	0.26 m
SourceCurr	entDraw Impostor Refelect 1.00		0.00 ms	0.00 m

Vater Refelect		1.00	3.04 ms	4.41 ms
WaterRef LisT	ranslucencyRender	2.55 ms	3.90 ms	2.77 ms
WaterRef Op	ResidueEffect	0.00 ms	0.00 ms	0.64 ms
WaterRef Ter	RenderWaterAndTranslucenc	y 2.55 ms	3.90 ms	0.64 ms
Draw Opague	UpdateWave	0.00 ms	0.00 ms	1.36 ms
Draw Terrair	InvFFT	0.06 ms	0.08 ms	0.79 ms
SourceCurre	RestoreRefraction	0.34 ms	0.48 ms	0.04 ms
Sourcecurre	RenderWaterSelf	0.00 ms	0.00 ms	0.04 ms
	RenderWaterSelf	0.00 ms	0.00 ms	
0	WaterRenderRef	口什如 2.10 ms	3.26 ms	
	RenderWaterSelf	0.02 ms	0.03 ms	

Hidden Buff of Reflection

- Thinking out of the box
 - Reflection and main Camera clipping together
- Results
 - Reflection and main Camera shared the results of Culling
 - Reflection and main Camera shared Instance Buffer filling
 - Reflection and main Camera became two unions, the performance will double when using head-up camera⁽³⁾
 - Whole scene reflected Impostor
- Philosophy behind
 - Seek common ground

Offline Impostor summary

- Increased the content of far scenes
- Drew more graphics, but brought better performance
- Graphic quality slightly degraded, but is still acceptable at a far distance coupled with fog
- Has passed the third test

Data Optimization

- Product-oriented
- Definition of appropriate resources
- In-depth analysis of gameplay concentrated areas
- Very good output

Data Optimization

- Rocks with mixing textures
- Model LOD
- Internal bounding box
- Vegetation data optimization

Rocks with mixing textures



Model Optimization

- LOD
 - Most models have lod, because the feature of lod/pop switching is not enabled
 - Dongyue case was quite a shock, so we decided to enable lod
 - Successfully resolved the problem of lod switching (screen door)
- The hair occupied too much two-sided triangles
 - Simplified, and enforced CW at a far distance
- Two-sided texture
 - Only a small part of model require two-sided texture
- AlphaTest
 - Only a small part of model require alphatest to split the models



Vegetation data optimization


Results of data optimization

124-12/1/24 - -----42/1/ FT cos TO BE A MERCELAR 28 33 1202 002 • First solved 杭州 57 59 ms 杭州:钱塘门 2084,1325 41 36 2162.1185 Brought cor 46 52 2011,923 28 35 • Shared the hd art 34 38 杭州:红衣林 1801.2773 开封 35 36 1997.1041 teams 33 39 开封:皇城 22 36 开封:羌山 28 36 1126,1250 开封:飞霞渡 天下镖 27 34 1292,1001 天下镖 1595,1258 34 44 开封:西水关 20 30 1473,2502 徐海 27 30 1460,2121 30 33 1176,1839 荆湖 32 34 1420,1114 35 36 荆湖:緊張圖 993,1018