Reflections and caustics

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Content

- Reflections
- Caustics
- Unreal Engine
- Unity
What they have in common

- Light
- Smooth surface
- Expensive
- Not strictly necessary

https://upload.wikimedia.org/wikipedia/commons/0/0f/Radiosity_-_RRV%2C_step_79.png
Reflections

- Common in real world
  - Water
  - Metals
  - Glass
- Supported by game engines

https://commons.wikimedia.org/wiki/File:Snow_White_Mirror_1.png
Reflections

- Ray tracing
- Path tracing
- Environment mapping
  - Sphere mapping
  - Cube mapping
- Planar reflectors
  - Stencil buffer
  - Texture mapping
Ray tracing

- Sharp
- Slow
- Has variations
  - Distributed ray tracing

https://upload.wikimedia.org/wikipedia/commons/9/93/Raytracing_reflection.png
Ray tracing

✧ Recursion
✧ Shoot ray from viewer
✧ On hit
  ◦ Calculate colour (based on light direction)
  ◦ If reflective/refractive cast new ray
Path tracing

- Global illumination
- Highly realistic
- Noisy

https://upload.wikimedia.org/wikipedia/commons/thumb/e/e0/Path_tracing_001.png/350px-Path_tracing_001.png
Path tracing

- Shoot ray from viewer
- Random direction from hit
- If light, return emittance
- Repeat two previous steps
- If no light, ignore ray
- Else recurse back (bidirectional reflectance distribution functions)
- Repeat previous steps a lot
- Get average
Environment mapping

- (reflection mapping)
- Efficient
- Dynamic reflections
- Reflecting reflective objects

https://upload.wikimedia.org/wikipedia/commons/3/31/Environment_mapping.png
Sphere mapping

- A single texture
- Has a lot of cons
  - Blind spot
  - Distortion away from the center
  - Dependent on camera position
  - Difficult to generate
Cube mapping

- Most popular
- Better than sphere mapping
- Cubes have six sides
Planar reflectors

- Flat(ish)
- At least two passes

https://upload.wikimedia.org/wikipedia/commons/2/25/Rolleiflex_Karuizawa_20101111_27.jpg

https://c1.staticflickr.com/5/4153/5014150890_eef7c77640_b.jpg
Stencil buffer

- Render reflected image
- Configure stencil buffer
- Draw reflector
- Erase everything outside the mirror
- Disable buffer
- Draw the rest
Texture mapping

- Draw reflected scene
- Store it in texture
- Redraw everything
Caustics

- Curved surface
- Global illumination

https://i.imgur.com/QJKZ3aL.jpg

https://thatsmaths.files.wordpress.com/2014/09/caustic-coffee-cup.jpg?w=300&h=222

http://i.imgur.com/QJKZ3aL.jpg
Caustics

- Photon mapping
- Texture
- Path tracing
Photon mapping

- Estimates
- Combining techniques
  - Direct illumination
  - Specular reflection

https://www.youtube.com/watch?v=ReI7AsF3nnE
Photon mapping

✧ Photon map(s)
  ✧ Scatter photons (Russian Roulette)
  ✧ Store them

✧ Rendering pass
  ✧ Caustics
  ✧ Indirect illumination

Texture

- Water surface
- Premade
- Light function

https://i.vimeocdn.com/video/580808357_1280x720.jpg
Unreal

- Planar reflections
- Screen space reflections
- Reflection probes
- Light functions

https://youtu.be/QGIKrD7uHu8?t=2490
Screen space reflections

- Default
- Only what’s on screen
- Efficient
Planar

- More accurate than SSR
- A bit more effort
  - Enable **Support global clip plane for Planar Reflections**
  - Restart
  - Planar reflection actor
Reflection probes

- Inaccurate
- Combine with lightmass
- Avoid static lights
Unity

- Screen space reflection
- Reflection probes

https://docs.unity3d.com/uploads/Main/PostProcessing-ScreenSpaceReflection-0.png
Screen space reflection

- More like planar reflection in UE
- Expensive
Reflection probes

- Cube mapping
- Realtime detrimental to performance
- Static sees static
Optimisation

- Decrease reflection quality
- Occlusion
- Baking
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