FAKULTÄT FÜR !NFORMATIK

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Diplomarbeitspräsentation

Reflections, Refractions and Caustics in a Mixed-Reality Environment

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Mixed-Reality Environment

In a mixed-reality environment, virtual objects are merged into a real scene. This augmentation offers great possibilities to present content in innovative ways.

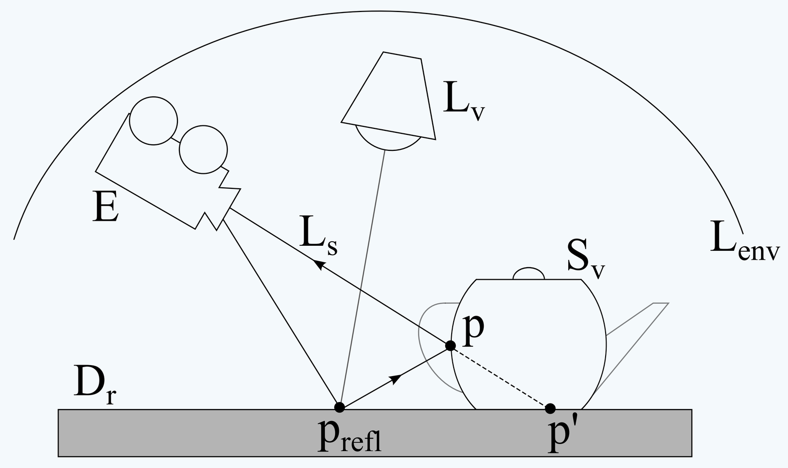
The emphasis of this thesis lies on a perceptually plausible light simulation for reflective and refractive objects in a mixed-reality environment, so virtual objects should seamlessly merge with the real environment.

Problem Statement

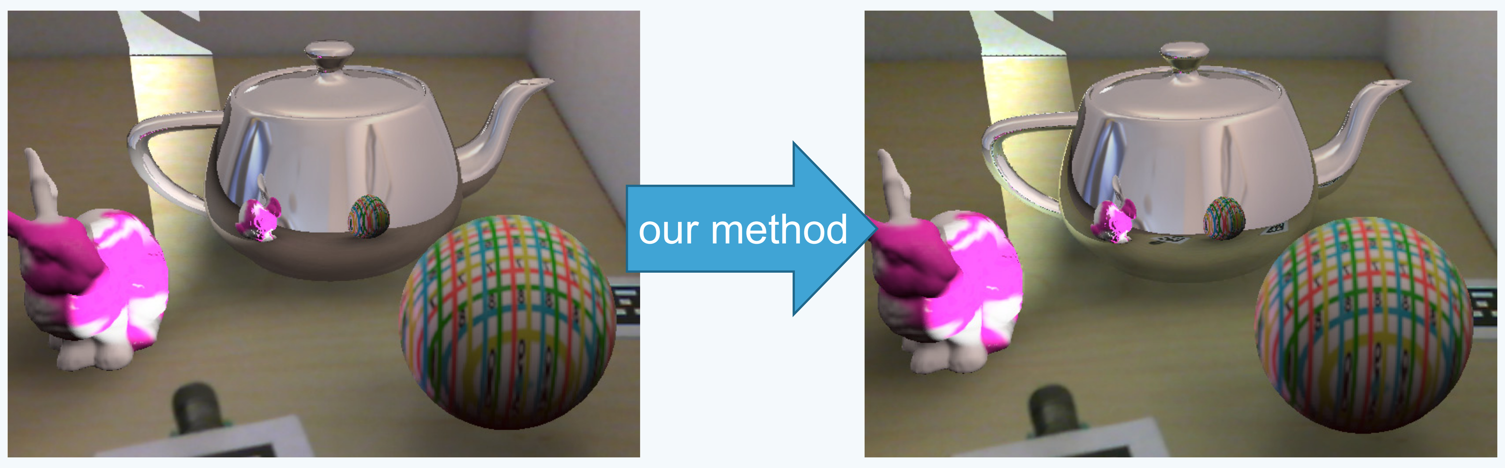
- Integrate light effects from reflective and refractive objects in a mixed-reality environment.
- Simulate caustics, which is a light focusing due to scattering.
- Compute these complex lighting effects in real time to handle the user interaction without delay.
- Apply the differential rendering effect also to reflected and refracted real surfaces.

Differential Rendering for Reflected and Refracted Surfaces

- Differential rendering (DR) is the fundamental method to merge virtual objects with a real scene.
- Reduces the error from the material approximation.
- Computes two light solutions:
  for real objects
  for real and virtual objects
  and adds their difference to the masked camera image.



- The problem is that the color value of the visible point p' has no relation to the reflected point p_{refl} in the camera image.



- The original DR algorithm uses only the estimated material (see the reflection of the desk in the teapot).
- Re-use information from the camera image by a back-projection of p_{refl}.
- Contributes to the overall impression.

Method

- Back-project reflected point (p_{refl})

and adjust the camera image when possible.

- Compute the two light solutions: for real and virtual only for real objects.

- Substitute missing geometry with an environment map.
- Compose the final image as $L_f = L_b + L_{env} + L_{rv} - L_r$.

- Differential rendering is also applied to reflected and refracted real objects.

Implementation

- Reflections, refractions and caustics were integrated into the RESHADE framework:
  light simulation for diffuse objects, based upon differential instant radiosity.
- Our method runs entirely on the GPU and achieves interactive to real-time frame rates.
- These effects were computed with three image-space methods:
  Reflective impostors, which reduce the intersection complexity.
  Refractions on the entry and the exit point of the ray.
  A fast splatting method to generate the caustic pattern.

Results

A real mirror reflects a virtual sphere. The light bounces multiple times (about 10 fps*).

A virtual spotlight illuminates a real bottle. It correctly refracts the scene behind and casts a virtual caustic onto the real desk (about 9 fps*).

A virtual colored glass on a real desk. The virtual light is scattered and appears as a caustic on the real desk (about 8 fps*).

*fps are frames per second on our test platform:
CPU: AMD-X2 3.1 GHz, GPU: NVIDIA GTX-260 896 MB

Contributions

- Extension for differential instant radiosity: integrate reflective and refractive objects.
- Handles various lighting situations: for real and virtual objects and light sources.
- Plausible simulation of caustics: until recently ignored in mixed-reality systems.
- Back-projection: Use differential rendering for reflections and refractions.

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