As we are dealing with a LC, the local correction has to be applied to the fragment-to-light vector before the fetching operation.

To render soft shadows we make use of mipmaps. We calculate a coefficient which is proportional to the distance from the pixel to the intersection point. The coefficient is then used to select a mipmap level so the more distant the pixel is from the intersection point the more blurred it gets.

Figure 4: *Soft shadows based on local cubemaps [Chess Room Shadows Demo 2016].*

3 Refraction based on local cubemaps

Refraction is an important effect to consider when striving for extra realism when rendering semi-transparent geometry. Refraction is the change in direction of a light wave due to a change in the transmission medium. When using cubemaps to implement refraction in a local environment, we need to apply the local correction to produce the correct results.

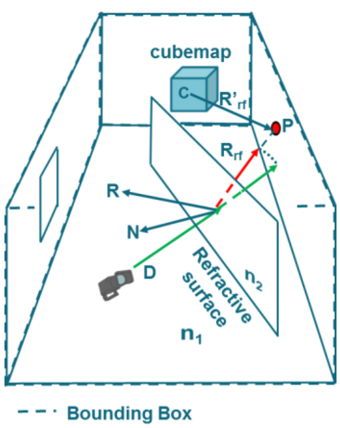

Figure 5: *The local correction to the refraction vector.*

According to the definition of LC provided in the section 1, to retrieve correctly the texture in the direction of the refraction vector R_{rf} we need to apply the local correction to it. After determining the direction of the refracted vector R_{rf}, we need to find where it intersects the bounding box of the local scene. The next step is to build a new vector R'_{rf} from the position where the cubemap was generated to the intersection point P and use this final vector to fetch the texel from the cubemap to render what is behind the refractive object. We get a physically based refraction because the direction of the refraction vector is calculated according to Snell's Law. Moreover, there is a built-in function we can use in our shader to find the refraction vector R strictly according to this law [Lopez Mendez 2015].

3 Solving limitations of local cubemaps

The new shadow technique introduced in section 2 enables rendering shadows from the static geometry of the boundaries of the scene. This technique works nicely in open plan spaces with no other geometry, especially in the center where the cubemap will likely be generated. Additionally, this technique won't produce shadows from dynamic geometry due to the static nature of the cubemap.

Nevertheless, the above mentioned limitations can be easily solved if we combine this technique with other well-known shadow rendering techniques, for example, shadow mapping. In this case all objects, and especially dynamic ones, are removed during the process of baking the cubemap. At runtime the shadows on the boundaries of the scene and on any object will be rendered using the local cubemap technique and the shadows produced by those objects will be rendered using the shadow mapping technique.

The same principle applies to solving the limitations of local cubemaps when rendering reflections. For example, reflections based on local cubemap can be combined with planar reflections rendered at runtime using the mirrored camera technique. The Ice Cave demo shows how shadows and reflections based on LC are effectively combined with other runtime rendering techniques.

4 Performance and quality

The static nature of the LC does have a positive impact in that it allows for faster and higher quality rendering. For example, shadows based on LC are 1.3 - 1.5 times faster than shadow mapping. The fact that we use the same texture every frame guarantees high quality shadows with no pixel instabilities which are present with other shadow rendering techniques.

Finally, as there are only read operations involved when using static LC the bandwidth use is halved. This feature is especially important in mobile devices where bandwidth is a limited resource. The conclusion here is that when possible, use rendering techniques based on LC. When combining with other techniques they allow us to achieve higher quality at very low cost.

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