Document Change History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Responsible</th>
<th>Reason for Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>February 21, 2007</td>
<td>KD, SM</td>
<td>Initial release</td>
</tr>
</tbody>
</table>

Go to [sdkfeedback@nvidia.com](mailto:sdkfeedback@nvidia.com) to provide feedback on Soft Shadows.
Soft Shadows

Abstract

Soft Shadows is an extremely useful feature in any computer game. According to the physics of light transport, sharp shadows can be created only by an ideal point light source, which means that the light source size is zero. In real life, lights of zero size don't exist. Therefore, shadows we see every day are soft and their softness varies depending on the light source.

This demo presents two algorithms for soft shadow rendering. The common advantage of the presented algorithms is that in contrast with standard PCF (Percentage Closer Filtering) algorithms, they do not use pseudo-random samples to sample the shadow map. That is why partially shadowed areas lack noise typically introduced by PCF algorithms.

The first algorithm tries to be physically accurate. It is more expensive, but gives results close to what one would see in real life. It accounts for the fact that shadow softness depends on ratio of two distances:

- From light source to light occluder
- From light source to shadow receiver

The second algorithm is more like a fixed kernel percentage closer filter. It softens the shadow by a constant user defined amount.

Kirill Dmitriev
NVIDIA Corporation
How It Works

The basic structure used by both algorithms is a min-max depth mipmap. A min-max mipmap is created from a standard shadow map. Suppose we have a 1024 × 1024 shadow map. On the first pass we create from it a 512 × 512 texture with two channels. The first channel of the coarser mip level contains the min of the four corresponding pixels in the finer mip level. The second channel contains the max of these four pixels.

Figure 1 shows the min-max mipmap creation, from four pixels of the finer level and we get one pixel on the coarser level.

Fast Algorithm

The fast soft shadow algorithm implements standard PCF with a fixed kernel. For example, for shaded fragment:

- It projects this fragment on to the shadow map
- It surrounds the point where it projects by square kernel $K \times K$ pixels
- It computes what is the number $C$ of pixels that are closer to light source than the fragment

Shadowing is then equal to $C/(K^2)$. If the kernel contains too many shadow map pixels, it is computationally expensive to compute the shadowing. Here is where the structure of the min-max mipmap comes to the rescue. Let’s denote the $z$ value of the current fragment as $Z_f$. We start looping through shadow map pixels at the most coarse $2 \times 2$ mip level of the mipmap. If $(Z_f < \text{min})$, none of the shadow map pixels can potentially cover the fragment and shadowing is 0. Alternatively, if $(Z_f > \text{max})$, all of shadow map pixels occlude the fragment from light and shadowing is 1. Third possible case is when $(\text{min} < Z_f < \text{max})$. In this case we can’t conservatively answer the shadow query and we have to descend down to finer levels of the min-max mipmap. We do it recursively until we reach the level where we can answer the shadow query conservatively. Worst case scenario, we reach the finest mipmap level where the situation $(\text{min} < Z_f < \text{max})$ is never possible because at that level $\text{min} = \text{max}$. 
Accurate Algorithm

The accurate algorithm works by back projecting the shadow map pixels on to the light source plane\(^1\) (Figure 2). It assumes that light source is a square of user-specified size hanging in 3D space. After back projection, it is straightforward to compute shadowing. We simply need to subtract areas of all projected pixels from the light source area. This is a very simple geometric task when performed in the light source coordinate system. In this system both light source and projected pixels are 2 dimensional AABBs (axis-aligned bounding boxes).

---

Notice

ALL NVIDIA DESIGN SPECIFICATIONS, REFERENCE BOARDS, FILES, DRAWINGS, DIAGNOSTICS, LISTS, AND OTHER DOCUMENTS (TOGETHER AND SEPARATELY, "MATERIALS") ARE BEING PROVIDED "AS IS." NVIDIA MAKES NO WARRANTIES, EXPRESSED, IMPLIED, STATUTORY, OR OTHERWISE WITH RESPECT TO THE MATERIALS, AND EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE.

Information furnished is believed to be accurate and reliable. However, NVIDIA Corporation assumes no responsibility for the consequences of use of such information or for any infringement of patents or other rights of third parties that may result from its use. No license is granted by implication or otherwise under any patent or patent rights of NVIDIA Corporation. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. NVIDIA Corporation products are not authorized for use as critical components in life support devices or systems without express written approval of NVIDIA Corporation.

Trademarks

NVIDIA and the NVIDIA logo are trademarks or registered trademarks of NVIDIA Corporation in the United States and other countries. Other company and product names may be trademarks of the respective companies with which they are associated.

Copyright

© 2007 NVIDIA Corporation. All rights reserved.