Directionality-Aware Rectilinear Texture Warped Shadow Maps

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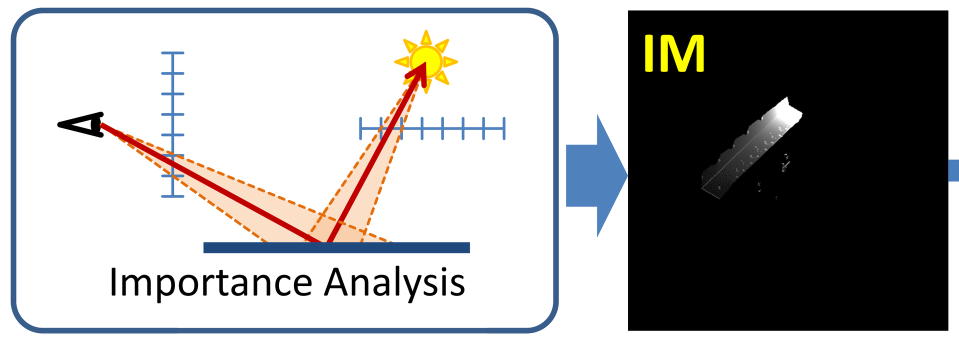
1. Introduction

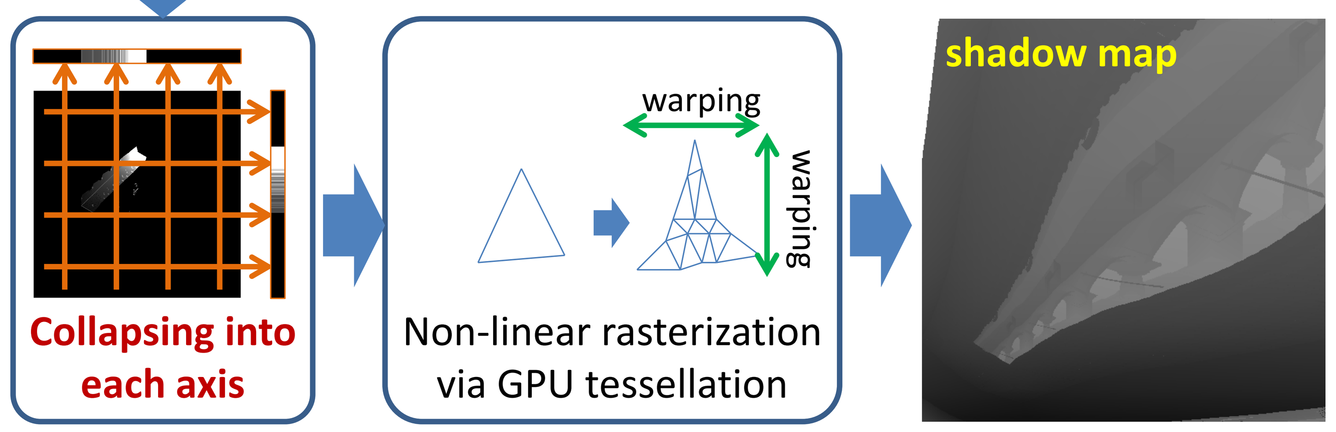
Rectilinear texture warped shadow mapping (RTWSM) [Rosen12] is a fast and adaptive technique. This technique controls the scene sampling rate via image warping according to a view-dependent importance map (IM). For RTWSMs, one issue is the impact of rotating the light's image plane. Since this plane is only warped with respect to its vertical and horizontal axes, the sampling rate depends on the angle of these axes. This poster proposes a fast technique to estimate an appropriate rotation matrix for RTWSMs by using principal component analysis (PCA) of the IM. Using this rotation, RTWSMs are able to perform more adaptively with small overhead.

2. Background



IM generation

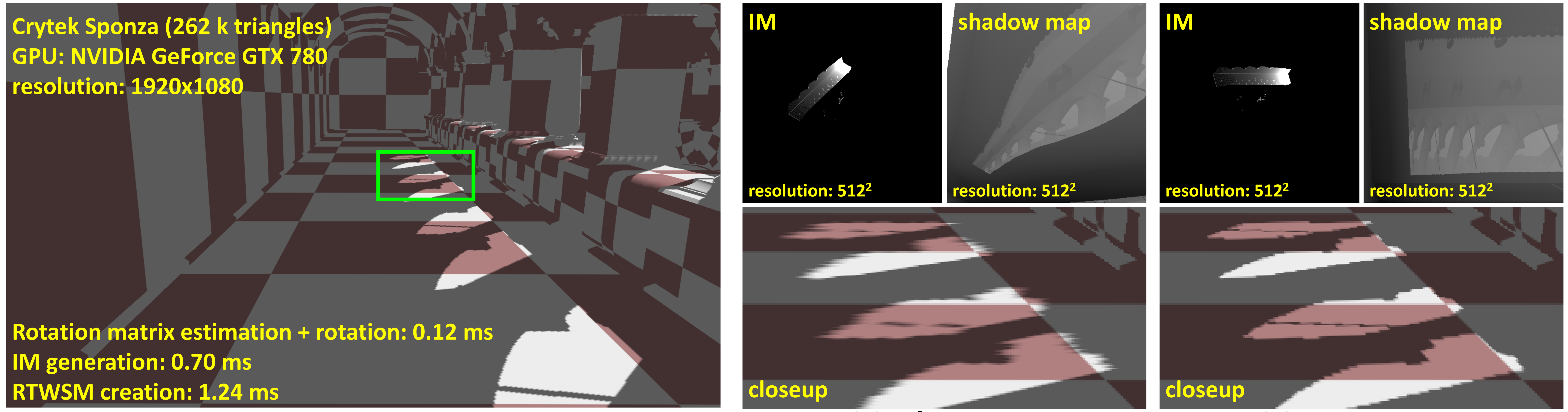
For RTWSM, an IM is first generated. Rosen [2012] proposed forward, backward, and hybrid analyses for the IM generation pass. This poster employs backward analysis, since forward and hybrid analyses can increase the importance of surfaces invisible to the camera, and often produce inappropriate importance distribution.



RTWSM Creation

After that, the IM is collapsed into each axis. The shadow map is warped according to these collapsed 1D IMs using non-linear rasterization for the adaptive scene sampling rate.

Due to the collapse of the IM, the sampling rate of RTWSMs depends on the angle of the IM's axes. Therefore, this poster rotates the light view frustum appropriately.

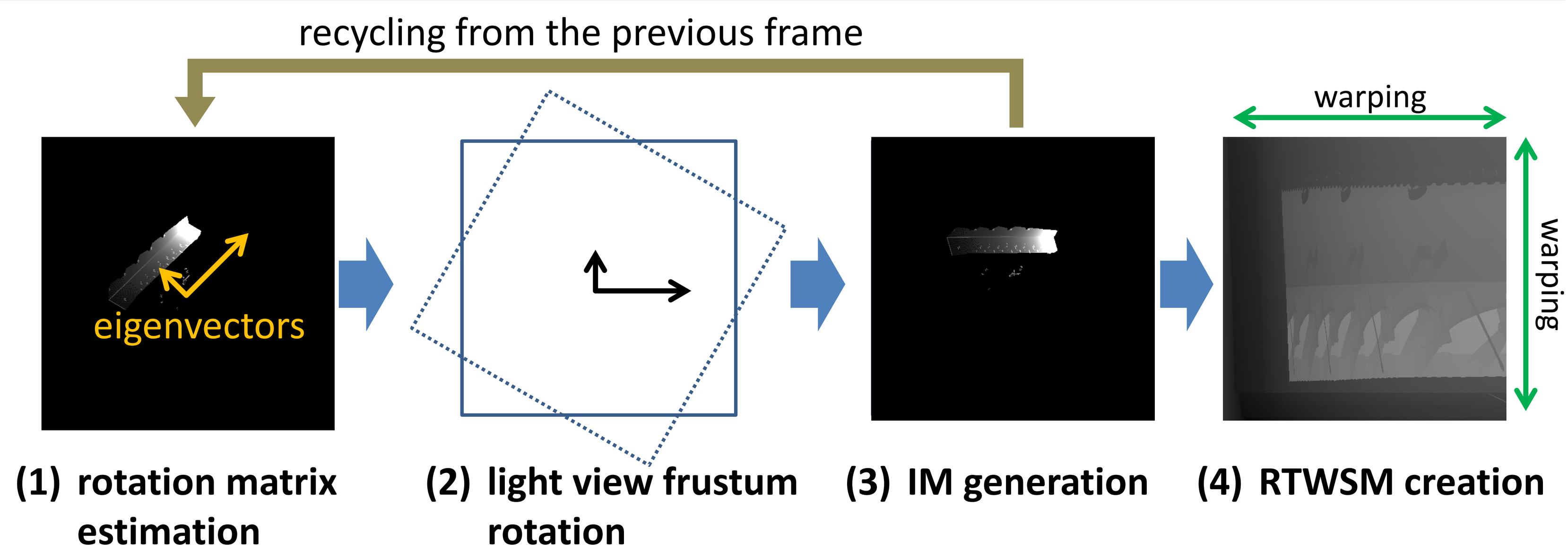


(a) w/o rotation (b) with rotation

Figure 1. Our technique (b) warps the shadow map more appropriately especially for regions distant to the camera. Thus, sharper shadows are rendered with **0.12 ms overhead**. RTWSMs without rotation produce moderate importance distribution for both vertical and horizontal axes when importance is obliquely distributed. By using our rotation, sharper importance distribution is produced for the vertical axis.

3. Our Method

Pipeline



Our contribution

(1) The rotation matrix is estimated by analyzing the IM of the **previous frame**.
(2) The light view frustum is rotated.
(3) The IM is generated using the rotated light view frustum.
(4) The RTWSM is created using the rotated light view frustum.

4x4 rotation matrix of the current frame *k*

$$\mathbf{R}_k = \mathbf{R}'\mathbf{R}_{k-1}$$

$\mathbf{R}_{k-1}$: the rotation matrix of the previous frame k-1
$\mathbf{R}_0$: the identity matrix
$\mathbf{R}'$: the relative rotation matrix between the two frames

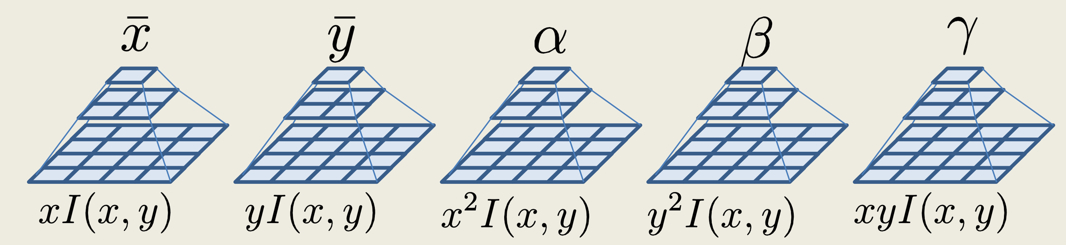
$\mathbf{R}'$ is obtained via **PCA of the IM** in the estimation pass (1).

Rotation Matrix Estimation via PCA

PCA is done with mipmap based covariance matrix calculation [Olano10].

$$\Sigma = \begin{bmatrix} \alpha - \bar{x}^2 & \gamma - \bar{x}\bar{y} \\ \gamma - \bar{x}\bar{y} & \beta - \bar{y}^2 \end{bmatrix}$$

covariance matrix of the IM



Averages are efficiently calculated by mipmapping.

The relative rotation matrix **R**′ is represented using the unit eigenvector (e_x, e_y) with the largest eigenvalue of the covariance matrix Σ

$$\mathbf{R}' = \begin{bmatrix} e_x & -e_y & 0 & 0 \\ e_y & e_x & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Temporal Coherence

Avoidance of Vibration When the imaged scene is not changed between consecutive frames, (e_x, e_y) = (1, 0) in theory. However, this eigenvector can have precision error, and thus the rotated view frustum can vibrate slightly. In order to avoid this vibration, $\mathbf{R}_k = \mathbf{R}_{k-1}$ is used if $e_x > 0.9999$.

Unnoticeable Delay Although our method uses the IM of the previous frame for PCA, any error due to delay is unnoticeable, because the rotation matrix is temporally coherent for most scenes.

References
OLANO, M., AND BAKER, D. 2010. LEAN mapping. In Proc. I3D'10, 181–188.
ROSEN, P. 2012. Rectilinear texture warping for fast adaptive shadow mapping. In Proc. I3D'12, 151–158.