

Perceptually base selective rendering

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Perceptually base selective rendering

- **Motivation**
- Problem description
- Previous work
- Research gap
- Future work

Motivation

- Rendering is the process of generating an image from a model, by means of computer programs.
- Now rendering high-fidelity images of complex scenes in a reasonable time is still a challenge in computer graphics, due to its high computation requirement.
- Since images are rendered to be viewed by humans, is it possible to make use of limits of human visual perception to speed up rendering?



Motivation

- Perceptually based selective rendering
- Which one looks better?



similar perceptual quality Vs. different rendering quality

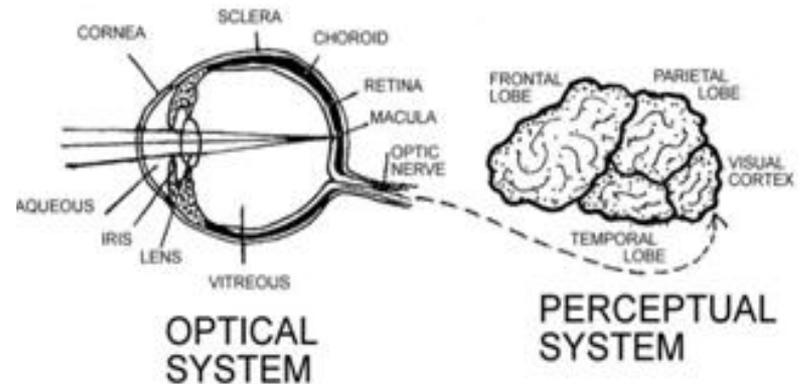
Perceptually base selective rendering

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Problem description

- Making use of limits of human visual perception to speed up rendering process
- Problems:
 1. Which human visual perception characteristics could be used?

Optical system characteristics:
such as nonlinear luminance
adaptation and visual masking.
Perceptual system characteristics:
mainly refer to visual attention
mechanism



2. How to make use of these characteristics?

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Previous work

- Using optical system characteristics
Optical system determines that human eyes' sensitivity to distortion is limited, i.e. not all distortions are visible.

Daly[1] proposed a visual difference predictor which could predict the visual difference between two input images. Then Bolin and Meyer [2] applied this predictor in rendering, they compared two continuous intermediate images to find regions which contain the largest errors, and assign more samples there. Recently, Overbeck et al.[3] developed a system adapting to variance in a multiscale wavelet hierarchy which corresponds closely to the human visual system.

[1] The visible differences predictor: an algorithm for the assessment of image fidelity, 1993. [2] A perceptually based adaptive sampling algorithm, SIGGRAPH, 1998. [3] Adaptive wavelet rendering, ACM Trans. Graph, 2009

Previous work

- Using perceptual system characteristics-- top-down and bottom-up visual attention mechanism

Itti et al.[4] proposed a human visual attention model, based on the fact that human tend to pay more attention to image region which “stands out” from its surrounding regions. Then Longhurst et al.[5] built a selective rendering system which exploits bottom-up visual attention. Recently, Lee et al. [6] exploited both top-down and bottom-up visual attention in rendering process in virtual environments.

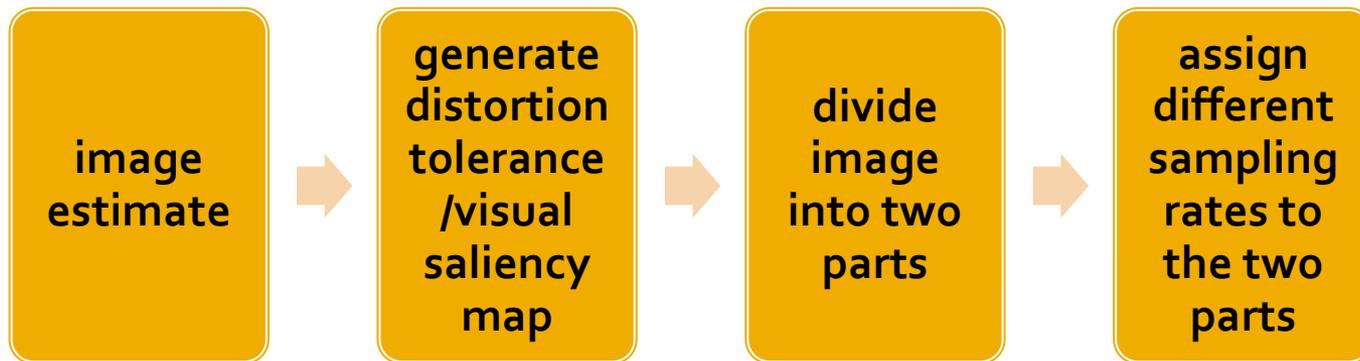
[4] A Model of Saliency-Based Visual Attention for Rapid Scene Analysis, IEEE Trans. on Pattern Analysis and Machine Intelligence, 1998. [5] A GPU based saliency map for high-fidelity selective rendering. In Proc. on Computer graphics, virtual reality, visualization and interaction, 2006. [6] Real-time tracking of visually attended objects in virtual environments and its application to LOD, IEEE trans. on visualization and computer graphics, 2009

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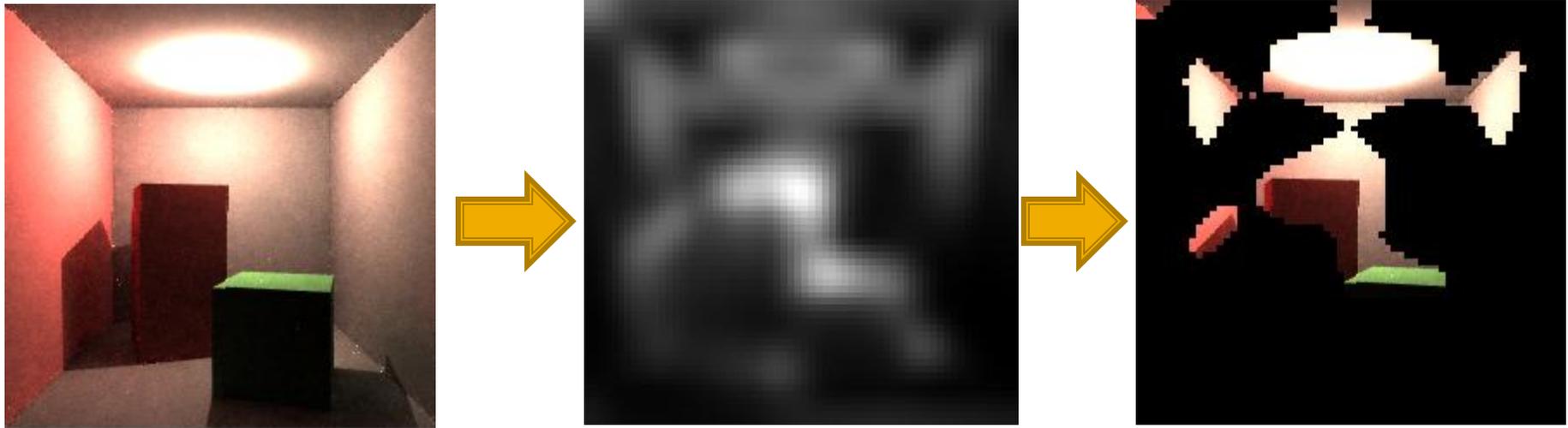
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Research gap

- One drawback of existing selective rendering methods is the way they assign samples.
- One way[5] of samples assignment is like this:



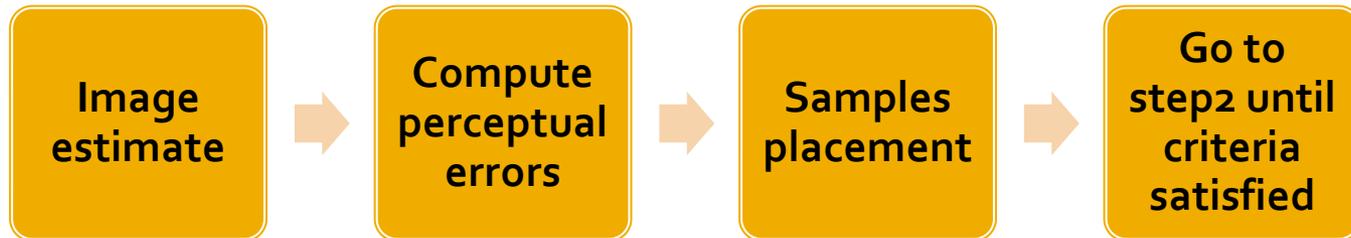
Research gap



- But in this method, the two sampling rates are determined empirically, it is possible to cause problems of under-sampling and/or over-sampling.

Research gap

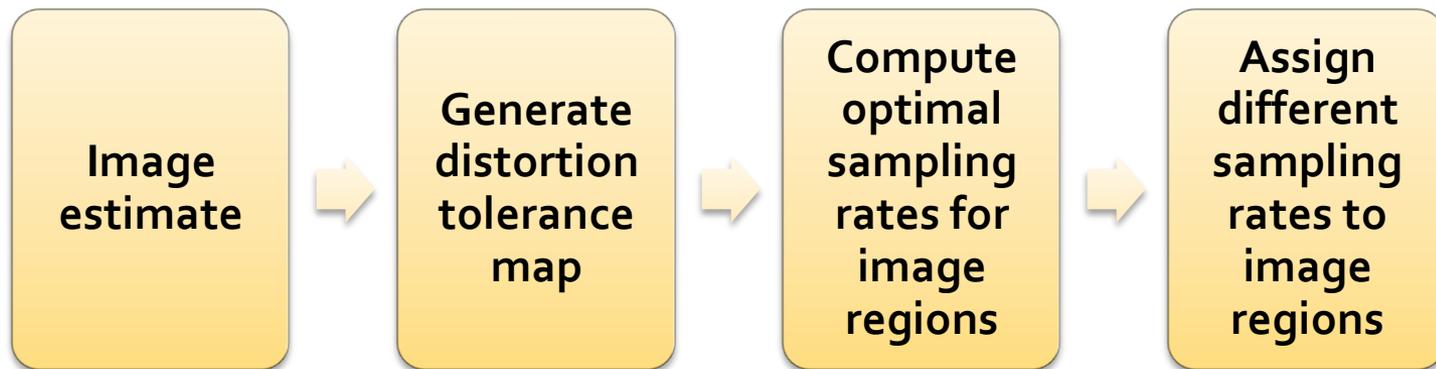
- Another way of samples assignment [2]



- Compared with the 1st method, this one produce better image quality, but since it includes recomputing the perceptual errors and checking stop criteria during rendering process, the computation requirement is quite high.

Research gap

- In order to solve these problems, we plan to first model perceptual quality with respect to sampling rate, and then based on the model, we could develop a selective rendering method like this:



- sampling rates for image regions are decided at the beginning part of rendering instead of being assigned dynamically during rendering process. And since the sampling value is derived from optimization, it is more efficient than empirical estimate.

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Future work

- 1. Model perceptual quality with respect to sampling rate
we could first decompose the image into $16*16$ macroblocks, and define: $q_i(r_i)=f(r_i, JND_i)$
- Here, q_i is the perceptual quality of i th macroblocks, it could be derived by comparing target macroblock with corresponding reference image block with Visual Difference Predictor. r_i is the sampling rate for i th macroblock. JND_i is the average just noticeable distortion[7] for i th macroblock, it gives the average visible distortion threshold for a macroblock, given the background luminance and texture condition in this block. In fact JND could be regarded as an indicator of image characteristics.
- We'll perform experiments and plot the curves of q , r and JND, and derive the equation of $q(r)$

[7] Xiaokang Yang, Weisi Lin, Zhongkang Lu, Motion-Compensated Residue Preprocessing in Video Coding Based on Just-Noticeable-Distortion Profile, IEEE trans. on CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, 2005

Future work

- 2. Optimization problem

$$\text{Max: } Q = \sum_i^N \alpha_i q_i$$

$$\text{Subject to: } \sum_i^N R_i N_p \leq N_{\text{samples}}$$

- The problem is that, given a total number of samples, how to optimally place the samples over the image plane to achieve the best perceptual quality.
- Here, Q is the overall perceptual quality of the image, it is the weighted sum of macroblocks' perceptual quality, α_i is the weight for different macroblocks, it could be the visual saliency value, meaning that visual salient region has a large contribution on the final image quality. N_p is the number of pixels in a macroblock.

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- Thank you for listening.
- Any question or suggestion?