Performance Improvement of Stochastic Rendering using CNN based Denoising

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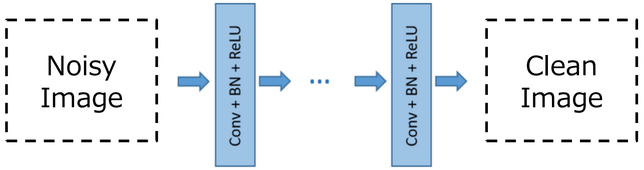
Introduction

Particle-based Rendering (PBR)

- Volume rendering by the stochastic process
- Does not require visibility ordering
- Produce high quality images by increasing the repetition

Convolutional Neural Network (CNN) Denoising

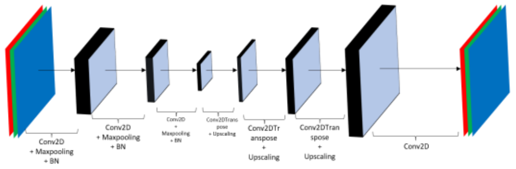
- Denoising by extracting feature maps via convolution
- Requires a set of noisy and clean image pairs for training
- Updates the shared-weight for the noisy image to output the clean image



Objective

Improve the performance of PBR with low repetitions by using our proposed CNN-based denoising method called as MkDAE (Multi-kernel Denoising Autoencoder).

Denoising Autoencoder (DAE)

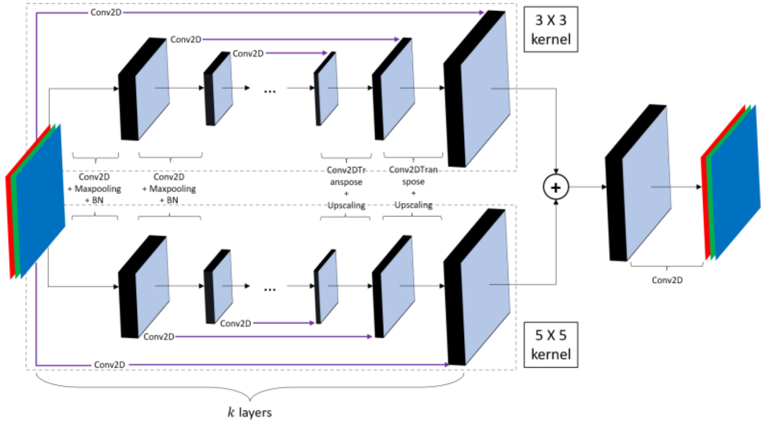


- An autoencoder (AE) downsamples inputs while extracting features
- The DAE extracts important features for denoising

Method

Multi-kernel Denoising Autoencoder (MkDAE)

- Makes use of multiple kernels for convolution

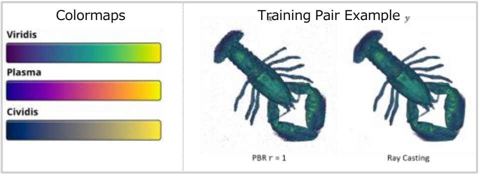


Mixed Loss Function

- Loss function composed of the mean-squared error (MSE) and structural similarity index (SSIM) loss

$$\mathcal{L}_{mix}(y,\hat{y}) = \alpha * \mathcal{L}_{SSIM}(y,\hat{y}) + (1-\alpha) * \mathcal{L}_{MSE}(y,\hat{y}), \qquad 0 \le \alpha \le 1$$

Result

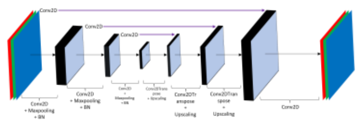


Dataset

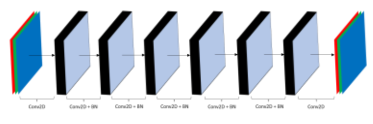
- Volume dataset
  - ✓ 11 volumes
- Training images
  - ✓ Coarse (PBR with r=1) and fine (Ray Casting) image pairs
  - ✓ Viridis, Plasma and Cividis colormaps
  - ✓ 20 images for each colormap for each volume
  - ✓ 20 X 3 X 11 = 660 pairs = 1320 images

Comparison results with previous work

- DAE, DAE w/ skip connection and DnCNN

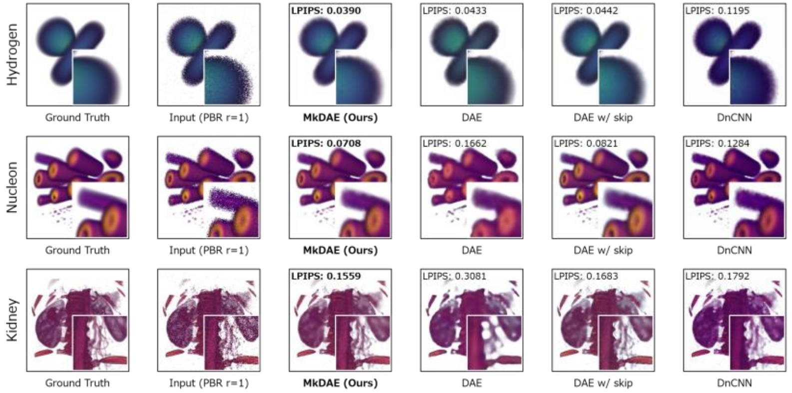


DAE w/ skip [Chaitanya et. al., ACM TOG, 2017]

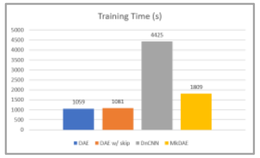


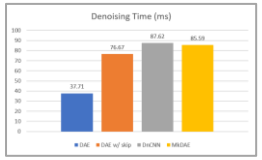
DnCNN [Zhang et. al., IEEE TIP, 2017]

- Image Quality



- Time Performance





Experimental setup

- ✓ Intel Xeon Gold 6238R CPU
- ✓ 368 Gb RAM
- ✓ NVIDIA Quadro RTX800 GPU

Software

- ✓ C++ & Python
- ✓ Tensorflow
- ✓ KVS (Visualization library)

Discussion

- Multiple kernels seem to improve the denoising quality of the denoising autoencoder
- Low repetitions of PBR with our MkDAE can replace high repetitions of PBR

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