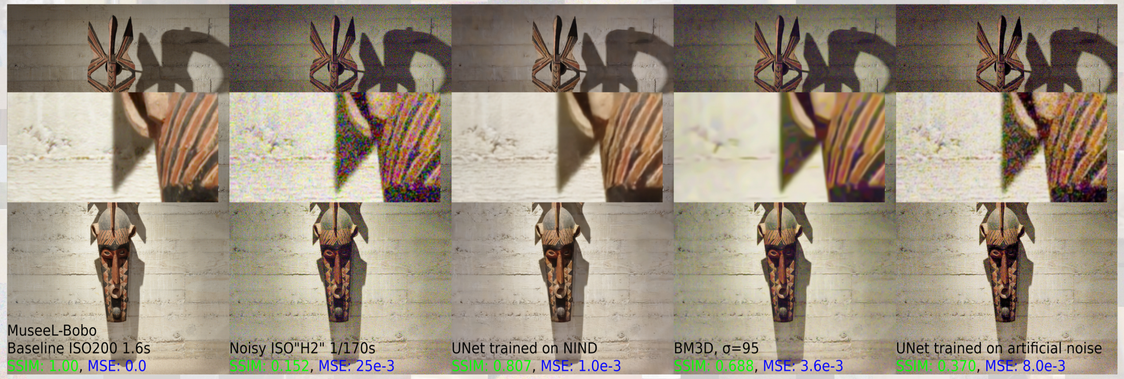
Image denoising using convolutional neural networks trained with naturally captured noise

Problem

- As shutter speed increases, the camera sensor must increase its ISO sensitivity and it ends up capturing more noise along with the real data.
- In many applications a slow enough shutter speed is not feasible. This may be due to a wide aperture which captures a larger depth of field but requires more light (slow shutter), a fast moving subject, or simply the lack of a steady tripod in a dark scene.
- The goal of this project is to exceed state of the art in noise removal
- Most current research on noise removal uses artificial (eg gaussian) noise for training (if applicable) and testing. Research has shown that artificial noise does not always translate into real-life performance.
- We captured a set of clean-noisy image sets and use it to train convolutional neural networks for image noise removal.



Current state

- Collected the Natural Image Noise Dataset (NIND)
- Trained various network architectures with different parameters using NIND: DnCNN, RedCNN, UNet
- RedCNN provides excellent performance, UNet achieves the same performance with a small fraction of the computing resources requirements

Natural Image Noise Dataset

- We created NIND - an open dataset of images with naturally captured noise - to effectively train neural networks on image denoising.
- Each image set is made of one or more base-ISO images taken in ideal conditions, and several images of the same scene taken with faster shutter speeds (and matching ISO sensitivities)
- The network is given a noisy image and receives feedback based on how closely its generated output resembles the baseline image for that scene.
- Training data: 72 sets = 426 images = 504696 crops = 4.65 gigapixels

Next step

- Our current network learns with the feedback it gets from a loss function: the Structural Similarity Index between the clean and denoised image. This loss function is not perfect and there are multiple possible mappings from a noisy to a cleaned image, therefore going for the best SSIM score results in blur.
  - → Switch to a Generative Adversarial Network: a different neural network is trained on discriminating between a baseline and denoised image and this network is used in place of the loss function
- Perform compression artifacts removal on JPEG and JPEG-XS, this will enable even higher compression ratios.