Homework 2: Denoising 2D Images with CNNs

Overview

In this task, you will implement and train a Convolutional Neural Network (CNN) to denoise low-resolution 2D lunar images. The dataset includes 1,000 pairs of noisy and clean 64x64 images. The noisy images were generated by downsampling and adding artificial noise. A well-structured CNN and standard training procedures (as discussed in the lectures) should achieve good performance on this dataset. *(See Figure 1 for an example of clean, noisy, and CNN-processed images.)*

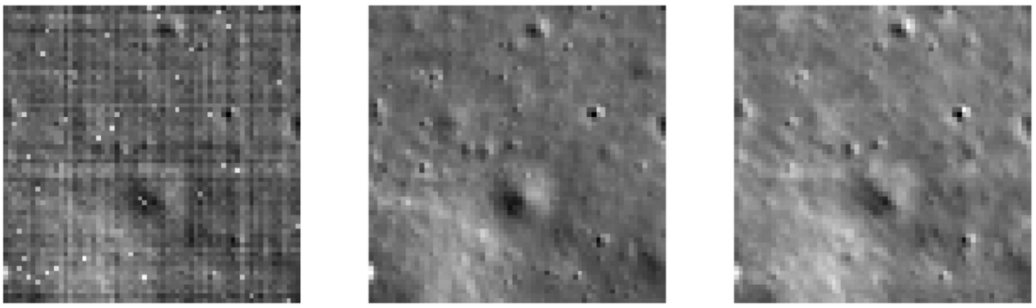

Figure 1: From left to right: Noisy image, clean image, denoised image

Training Data: Provided in *noisy_images_small_1k.npy* and *clean_images_small_1k.npy*

Tasks

1. **Model Implementation:**
    - Create a CNN model (feel free to use last week's homework as a starting point).
    - Train your CNN on the provided training dataset.
    - Find suitable hyperparameters to obtain a good fit.
2. **Report (No need to hand it in):**
    - A short discussion of any challenges you encountered and how you solved them.
    - The plots requested in Task 3.
3. **Visualization and Analysis:**
   Include the following plots and commentary in your report:
    - **Training & Validation Curves:** Plot **training** and **validation** loss versus epochs and comment on the trends. Validation loss should be obtained by leaving out **5%** of the total sample size during training and evaluating these held-out samples
    - **Learned Filters:** Visualize some of the learned convolutional filters and provide insights on what they might be capturing.
    - **Image Comparisons:**
        1. From the **training set**, select a single image and show three versions: the original clean image, the noisy image, and the CNN-denoised output. Comment on how well the model has denoised the image.
        2. From the **5% validation set** (the held-out set used for validation), select one image and again show the clean, noisy, and CNN-denoised images. Compare the quality of denoising on this unseen validation image with the results observed on the training image. Discuss any differences you notice.