EE 367
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2/23/24

Project Proposal: Video Denoising Method Comparisons

Motivations

Image denoising is the process of reconstructing or estimating a ground truth image from a noisy image. From a consumer's point of view, this is an important process because it can help correct and aid in taking a visually appealing photo under conditions that aren't necessarily conducive to the task. From a research and development perspective, denoising is critical for any process that involves any form of image and information identification.

The basic process behind denoising is that similar pixels in one area are averaged in order to reduce noise in said area of an image [1]. There are many variations and improvements of this idea that exist today, and these techniques have different tradeoffs that make them optimal for different uses. While the scope of EE 367 has covered denoising with respect to images, there is an entire area of denoising videos that has not been discussed. The motivation and aim of this project is to test and compare the ability of the BM3D denoising method with other techniques covered in class with respect to video denoising.

Related Work

Current denoising methods fall into the categories of classical, transform-based, or convolutional neural network- (CNN) -based techniques [2]. For the scope of this project, there is a focus on BM3D which is a non-local means method that is classified as a transform-based technique.

Non-local means denoising methods use a weighted average of surrounding pixels in order to estimate the value of a pixel in a similar region. It is preferred to local denoising methods because it properly handles images with large amounts of noise. BM3D specifically is a non-local method developed by Dabov et al. [3] that uses collaborative filtering on 3D data arrays (referred to as "groups") of 2D image fragments. Collaborative filtering is a procedure that involves a 3D transformation of a group, shrinking the transform spectrum, and a subsequent inverse transform of the 3D group. The result of the filtering, after returning the groups to their original positions in the image, is an estimate of the ground-truth image. BM3D was later improved by adding principal component analysis (PCA) [4] which groups mutually similar adaptive-shape neighborhoods. BM3D struggles if the noisy image is too sparse. So the benefit of incorporating PCA is that the true signal's sparsity is improved, which therefore improves the effectiveness of BM3D's filtering.

Project Overview

Throughout the scope of the course we have looked into a couple methods of image denoising. However, it is possible to use these methods for video denoising by applying the

techniques to each frame of a video. This project will evaluate different video denoising methods on a small dataset of very short video clips. The denoising methods discussed in class will be applied to the dataset videos frame-by-frame and compared to both the performance of BM3D and video denoising version of BM3D that was also developed by Dabov et al. [5]. All methods will be assessed both by visual inspection and by comparing PSNR.

Timeline

Week 1 (2/25 - 3/2):

- Find/create noisy video dataset
- Implement BM3D and video BM3D

Week 2 (3/3 - 3/9):

- Compare results to other methods from course

Week 3 (3/10 - 3/15):

- Fix bugs + finish comparison
- Create poster by 3/13
- Write final report by 3/15

References

[1] G. Wetzstein (2023), Stanford University *Digital Photography II: The Image Processing Pipeline* [Powerpoint slides]. Available: https://stanford.edu/class/ee367/slides/lecture4.pdf

[2] Fan, L., Zhang, F., Fan, H. *et al.* Brief review of image denoising techniques. *Vis. Comput. Ind. Biomed. Art* 2, 7 (2019). https://doi.org/10.1186/s42492-019-0016-7

[3] K. Dabov, A. Foi, V. Katkovnik and K. Egiazarian, "Image Denoising by Sparse 3-D Transform-Domain Collaborative Filtering," in *IEEE Transactions on Image Processing*, vol. 16, no. 8, pp. 2080-2095, Aug. 2007, doi: 10.1109/TIP.2007.901238.

[4] Dabov, Kostadin, et al. "BM3D image denoising with shape-adaptive principal component analysis." *SPARS'09-Signal Processing with Adaptive Sparse Structured Representations*. 2009.

[5] K. Dabov, A. Fol, and K. Egazarian, “Video denoising by sparse 3D transform-domain collaborative filtering,” *Proc. 15th European Signal Processing Conference, EUSIPCO 2007,* Poznan, Poland, September 2007.