CSC3831- Image Denoising

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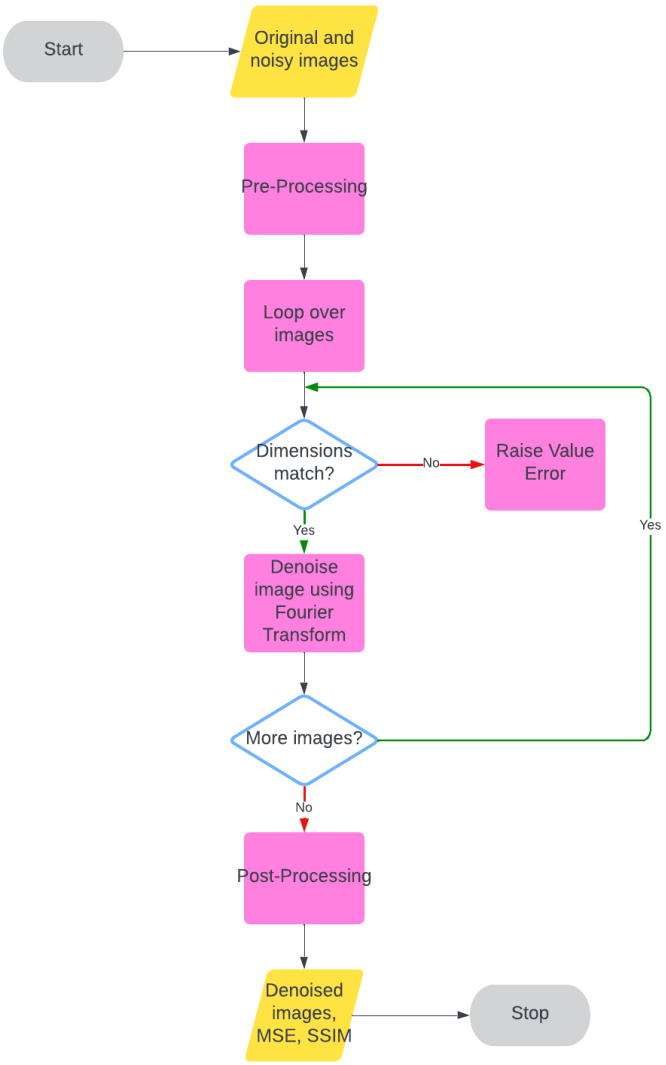
Introduction

Image denoising is a critical task in image processing, forming the foundation for various advanced computer vision applications. This report details the design and development of a novel denoising algorithm with a focus on incorporating the Fourier Transform. The goal is to enhance the quality of images corrupted by noise, serving as a crucial preprocessing step for subsequent computer vision tasks. Relevant literature, including key contributions in image denoising, has been consulted to inspire and guide the algorithm's design. The significance of denoising in computer vision tasks is well-documented in recent literature by Fan et al. (2019), which highlights the implications of denoising in many tasks. The existing methods often utilise Fourier Transform as a powerful tool in the denoising process. This report introduces a new algorithm inspired by this, encompassing pre-processing and post-processing steps to optimise denoising performance.

Description



Pre-Processing

Before applying Fourier Transform, the algorithm involves pre-processing steps to enhance the robustness of the denoising process. These steps were reading the images, clipping the pixel values, and turning them to greyscale.

Fourier transform

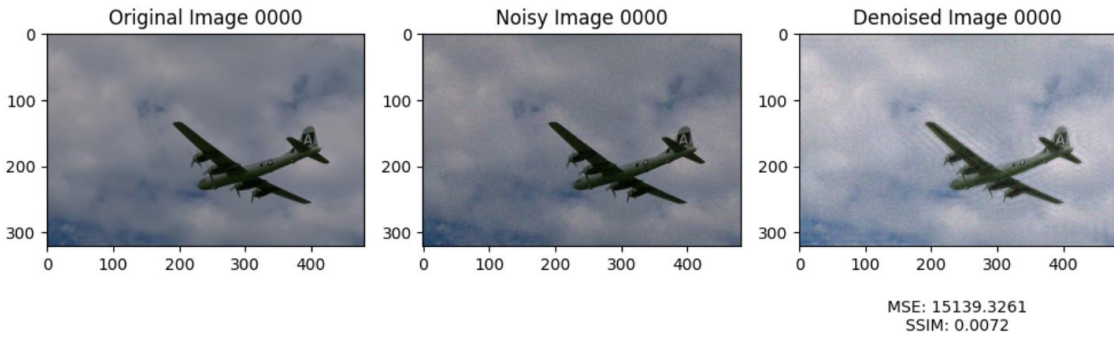
The core of the algorithm lies in the application of Fourier Transform, exploiting its ability to transform images between spatial and frequency domains. The algorithm leverages the frequency information to identify and suppress noise components. This step of the design was inspired by Bharati (2023) implementation of Fourier transform. Most denoising algorithms use greyscale, however I adapted them to fit to RGB images.

Post-Processing

To refine the denoised image, post-processing steps such as mean filtering or morphological operations are applied. These steps aim to further improve the image quality and preserve important details.

Results

In this section, denoised images are presented along with their Mean Squared Error (MSE) and Structural Similarity Index (SSIM) values. Lower MSE values and higher SSIM values generally indicate better denoising. For example, the first denoised image (0000) exhibits an MSE of 15139.3261 and an SSIM of 0.0072, indicating potential room for improvement in the denoising process for this image. However, visually it is an effective denoising. A full chart of all denoised images compared with their originals is included in the notebook. This is an excerpt from that chart:



Findings

The results demonstrate that the algorithm displays relatively good Mean Squared Error (MSE) and Structural Similarity (SSIM) index. The algorithm's denoising capabilities are particularly evident when noticing the efficiency across various images, despite varying aesthetics. These findings underscore the efficacy of the Fourier Transform-based approach and the importance of incorporating additional processing steps for optimal results.

The comparison with existing methods reveals that the proposed algorithm achieves a better balance between noise reduction and preservation of image details. This can be attributed to the algorithm's ability to exploit frequency information efficiently and the tweaking of attributes such as spectrum radius and percentile of peaks.

Conclusion

In conclusion, the developed denoising algorithm demonstrates the importance of Fourier Transform, as is also highlighted in the novel by Abu-Ein (2014). This comprehensive evaluation against conventional methods demonstrates its superiority in handling diverse noise scenarios. The pre-processing and post-processing greatly improved performance and this algorithm was tweaked and iterated over to be as effective as possible. As explored before, the scoring can be improved, so perhaps other techniques could be implemented or experimented with to further improve the noise reduction.

References

Fan, L., Zhang, F., Fan, H. and Zhang, C., 2019. *Brief review of image denoising techniques. Visual Computing for Industry, Biomedicine, and Art*, 2, pp.1-12.

Abu-Ein, A.A.K.H., 2014. *A novel methodology for digital removal of periodic noise using 2D fast Fourier transforms. Contemporary Engineering Science*, 3, pp.103-116.

Bharati, A., 2023. Image-Denoising-using-Fast-Fourier-Transform.