FA-UNet: An Attention-UNet-based Frequency Domain Image Denoising and Deblurring System

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Motivation

- **Challenges in Image Restoration**
  Digital images often suffer from blur and noise, impacting clarity and usefulness, especially in critical areas like medical imaging and satellite photos.
- **Limitations of Current Methods**
  Most existing solutions work in the spatial domain, adjusting pixels directly, while methods works in the frequency domain have not been fully studied.
- **Advantages of Frequency Domain**
  The frequency domain representation allows for more effective separation and identification of image components based on their frequency characteristics
- **Incorporation of Attention Mechanisms**
  Attention mechanisms are utilized in the frequency domain, to target specific areas most affected by noise and blur.

Related Work

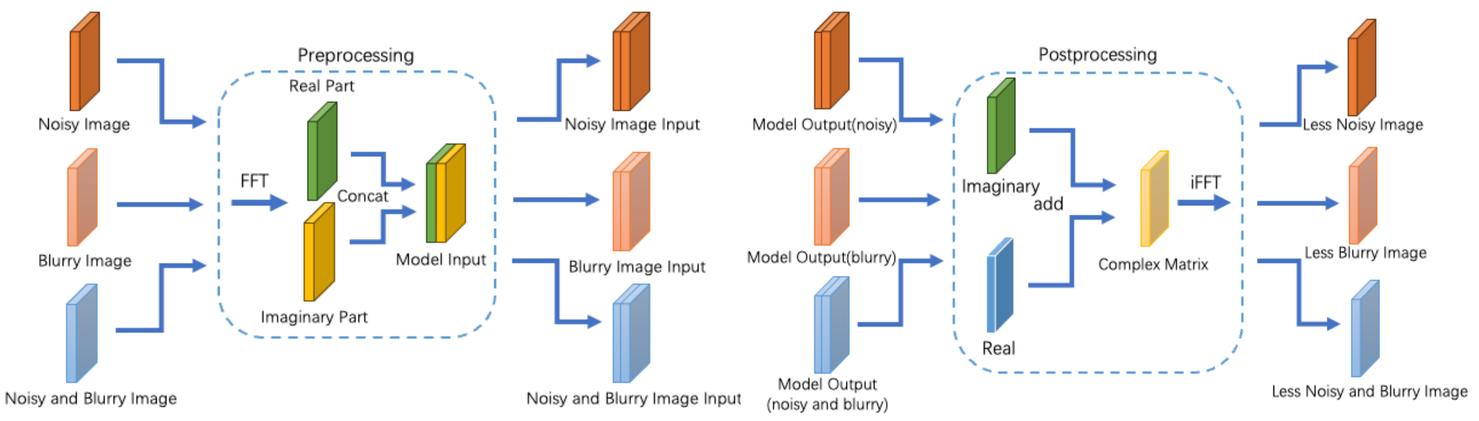
- The **Vision Transformer (ViT)** architecture has been shown remarkable success in image restoration. However, it needs more data than CNN methods to achieve satisfying results [1].
- As a powerful variant of CNN, **U-Net** [2] has also been applied to image denoising tasks. Alom et al. proposes **R2U-Net** [3] for image segmentation that combines residual connec tion, RCNN and U-Net. Oktay et al. [4] Proposed a novel **attention gate (AG) model** for medical images.
  We combine the architecture of these two UNet-based models and apply it in our image restoration task.

References

[1] Ali, Benjdira, Koubaa, et al. Vision transformers in image restoration: A survey. Sensors, 2023
[2] Ronneberger, Fischer, Brox. U-net: Convolutional networks for biomedical image segmentation. Medical Image Computing and Computer-Assisted Intervention–MICCAI, 2015
[3] Alom, Hasan, Yakopcic, et al. Recurrent residual convolutional neural network based on u-net (r2u-net) for medical image segmentation. arXiv preprint, 2018
[4]Oktay, Schlemper, Folgoc, et al. Attention u-net: Learning where to look for the pancreas. arXiv preprint, 2018

New Technique

- **Frequency Domain Image Processing**
  Novel processing pipeline for deblurring and denoising images in the frequency domain.
- **Real and Imaginary Component Integration**
  Integrated real and imaginary parts of image components in Fourier domain during image pre-processing phrase to gather as much image information as possible.
- **Attention Mechanism in Frequency Domain**
  Distinguished between low-frequency blur and high-frequency noise by attention mechanism to better localize image recovery zone.
- **Optimized Performance in Frequency Domain**
  Utilized Attention R2U model structure to enhance deblurring and denoising performance.



Experimental Results