



# MFmamba: A Multi-function Network for Panchromatic Image Resolution Restoration Based on State-Space Model

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## Introduction

Remote sensing images are becoming increasingly widespread in military, earth resource exploration. Because of the limitation of a single sensor, we can obtain high spatial resolution grayscale panchromatic (PAN) images and low spatial resolution color multispectral (MS) images. Therefore, an important issue is to obtain a color image with high spatial resolution when there is only a PAN image at the input. The existing methods improve spatial resolution using super-resolution (SR) technology and spectral recovery using colorization technology. However, the SR technique cannot improve the spectral resolution, and the colorization technique cannot improve the spatial resolution. Moreover, the pansharpening method needs two registered inputs and can not achieve SR. As a result, an integrated approach is expected. We designed a novel multi-function model (MFmamba) to realize the tasks of SR, spectral recovery, joint SR and spectral recovery through three different inputs. Firstly, MFmamba utilizes UNet++ as the backbone, and a Mamba Upsample Block (MUB) is combined with UNet++. Secondly, a Dual Pool Attention (DPA) is designed to replace the skip connection in UNet++. Finally, a Multi-scale Hybrid Cross Block (MHCB) is proposed for initial feature extraction. Many experiments show that MFmamba is competitive in evaluation metrics and visual results and performs well in the three tasks when only the input PAN image is used.

## What are the main challenges in food image generation ?

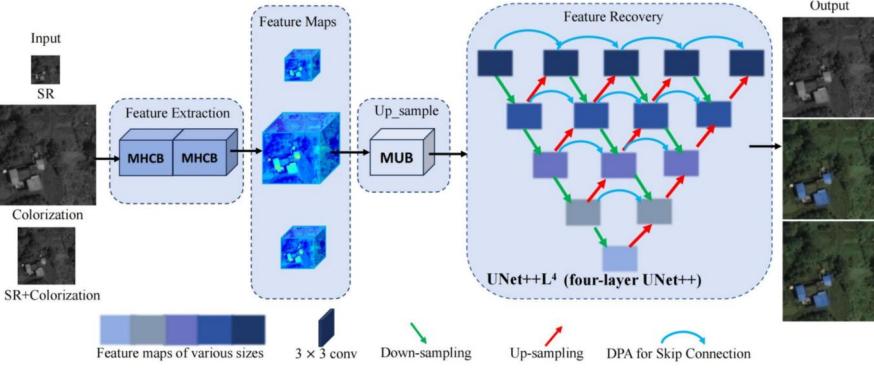
**(a) Complex and Diverse Data Content.** Remote sensing images exhibit high complexity and diversity, with substantial variations across different regions and acquisition conditions. Their intricate scenarios and features thus demand more advanced model architectures.

**(b) Independent Task Execution.** Current models are tailored to individual tasks in isolation, whereas literature on integrating both tasks into a unified framework remains scarce. It is therefore imperative to explore the inherent commonalities and correlations between the two tasks for joint optimization.

## Main contributions:

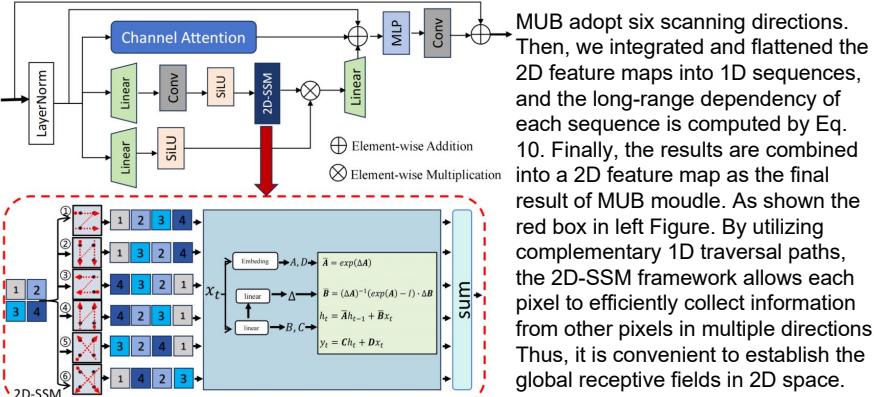
- ◆ We design an efficient PAN image resolution restoration network to produce colorized HR images. The proposed Mamba Upsample Block (MUB) adopts a state space model for resolution restoration.
- ◆ We design a Multi-scale Hybrid Cross Block (MHCB) for shallow feature extraction, which can detect local and multi-scale features effectively and improve the ability of detail feature extraction.
- ◆ We introduce a novel Dual Pool Attention (DPA) to improve feature representation by dynamically adjusting channel weights so that the model may focus on more important feature channels.

## Method

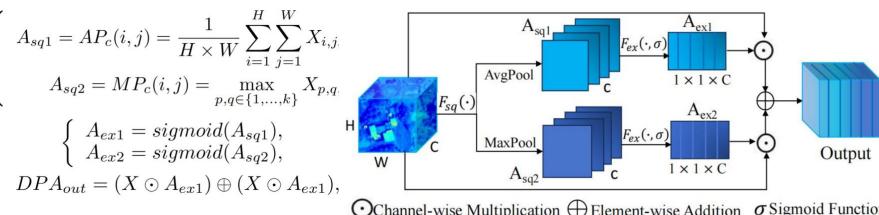


We propose a multi-function model (MFmamba) based on UNet++ and mamba, which can realize the tasks of SR, spectral recovery, and joint SR and spectral recovery of PAN image. Fig. 1 is the overall structure of our proposition. We combine the Mamba Upsample Module (MUB) constructed utilizing the state space model with UNet++ and design a novel Dual Pool Attention (DPA) to replace the original skip connection in UNet++ for information transfer between the same-level feature maps. Multi-scale Hybrid Cross Block (MHCB) is designed to extract multi-scale features through convolution operations with different convolution kernel sizes.

### Mamba Upsample Module (MUB)

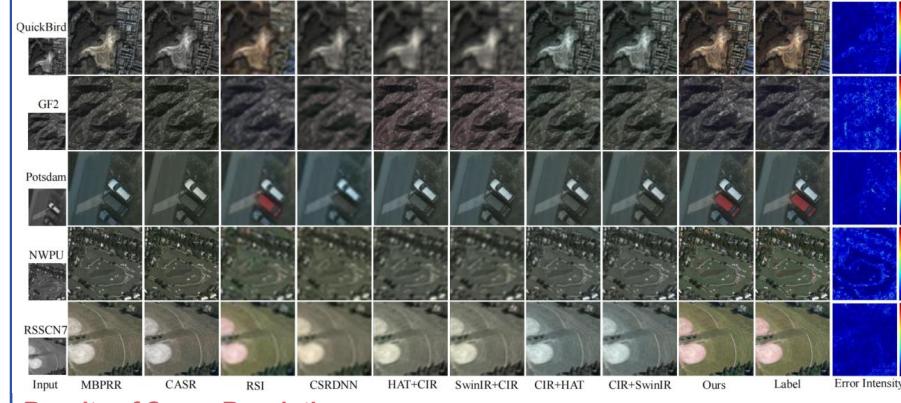


### Dual Pool Attention (DPA)

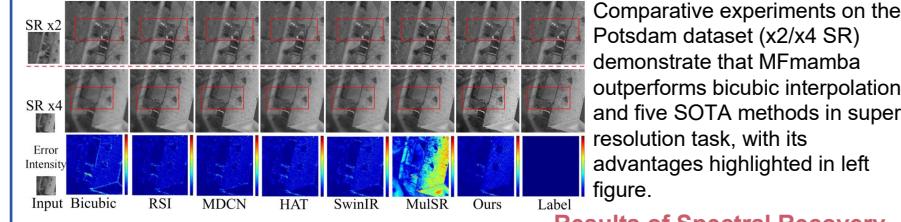


## Experiments

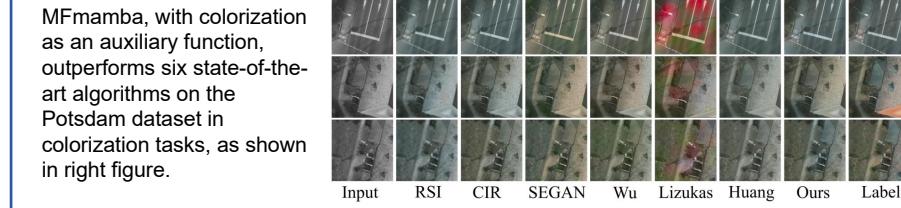
### Results of Joint SR and Spectral Recovery



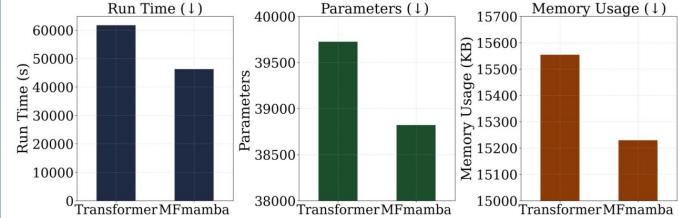
### Results of Super-Resolution



### Results of Spectral Recovery



### Comparison Between Mamba and Transformer



Replacing MUB's Mamba module with Transformer in Potsdam dataset experiments shows our Mamba-based model is faster with fewer parameters.

## Conclusion

We proposed MFmamba, a multifunctional resolution recovery model for remote sensing images; incorporating the MUB module, MHCB, and DPA attention mechanism, it achieves excellent performance in spatial/spectral/joint resolution recovery tasks and outperforms most existing models, verifying the effectiveness of a single multi-task framework.