Hyperspectral Image Superresolution Using Spectrum and Feature Context

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The purpose and method of this paper

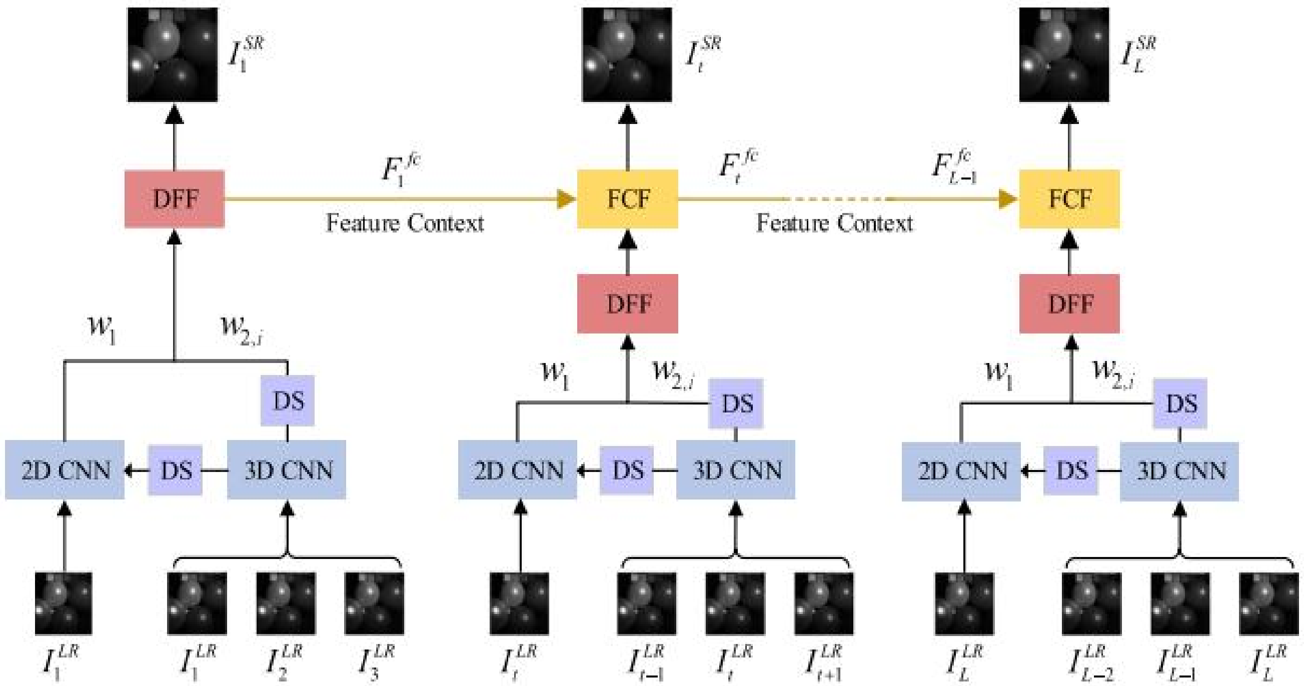
This method uses the **spectral** and **feature context** information and combines with the **two-channel convolutional neural network** (CNN) to improve the quality of hyperspectral image reconstruction.

The research methods are summarized as follows:

New input network method: apply the current band and its two adjacent bands to perform single-band SR(SuperResolution).Through the way of recurrence, the reconstruction of the hyperspectral image is achieved.
Dual channel network design: The dual-channel network contained 2D CNN and 3D CNN, which is designed to jointly exploit the information of single band and adjacent bands by depth split (DS)
Feature transfer: The features that have been extracted from the previous band SR task are fed into the network of current band. It not only facilitates the complementarity of information, but also simplifies the network structure so that there is no need to design more branches.

Proposed Method

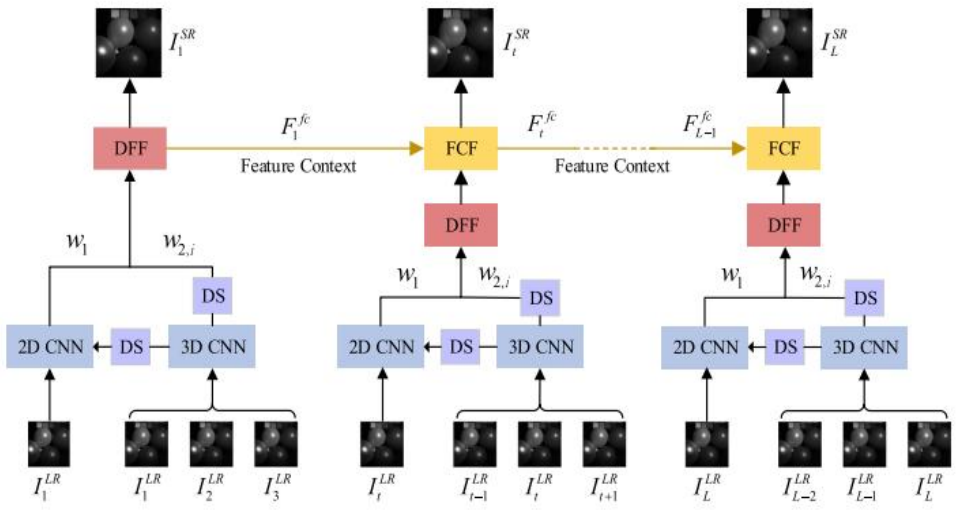
Network Structure



The overall structure contains 2D CNN, 3D CNN, dual-channel feature fusion (DFF), and feature context fusion (FCF)

Proposed Method

Network Structure



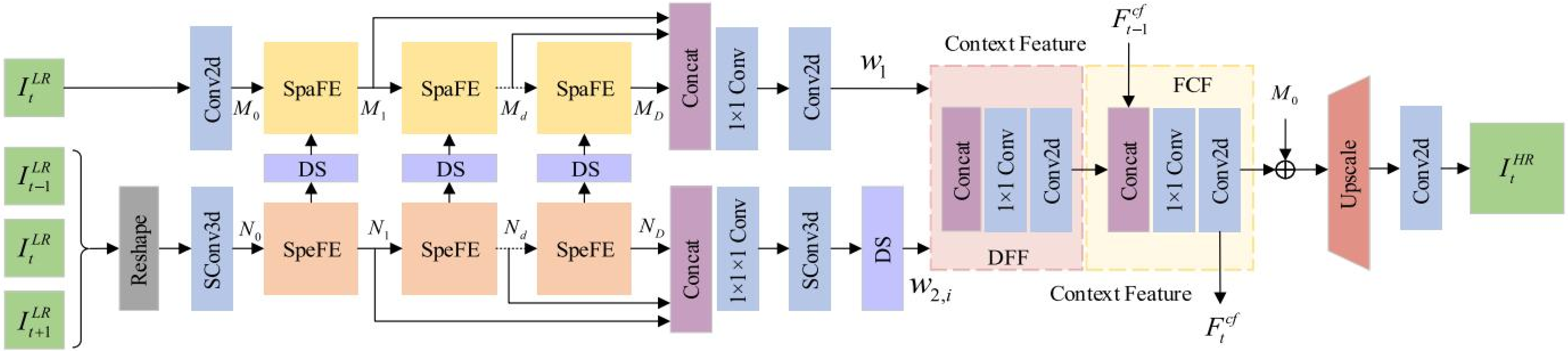
First, the single band is fed into 2D CNN to exploit the spatial information.
The adjacent bands are input to 3D CNN to extract the spatial and spectral features simultaneously.
Under depth split (DS), the network adaptively preserves the valid information learned from both channels with the help of dual-channel feature fusion (DFF).
Then, the features learned in the previous band are transferred to the reconstruction of the current band. Through feature context fusion (FCF), a single estimated band is obtained.
After many such steps, we finally obtain the reconstructed hyperspectral image.

Proposed Method

TABLE I
ANALYSIS OF THE INFLUENCE OF THE NUMBER OF THE MODULE D IN TWO SUBNETWORKS ON THE PERFORMANCE

Evaluation metric	3	4	5	6	7
PSNR	44.937	45.144	45.300	45.340	45.401
SSIM	0.9736	0.9738	0.9739	0.9739	0.9739
SAM	2.233	2.225	2.217	2.216	2.215

Overall architecture of the proposed dual-channel network.



SpeFE (Spectral Feature Extraction) layer is a neural network layer specially designed for extracting spectral features. It is mainly used to process image, audio or other signal data, by analyzing the spectral information of these data to extract useful features

Results on the X2 scale

TABLE IV

QUANTITATIVE EVALUATION OF STATE-OF-THE-ART SR ALGORITHMS BY AVERAGE PSNR/SSIM/SAM, PARAMETERS, AND RUNNING TIME FOR DIFFERENT SCALE FACTORS ON THREE DATASETS. THE RED AND BLUE COLORS INDICATE THE BEST AND SECOND BEST PERFORMANCE, RESPECTIVELY

Scale	Method	Params	CAVE		Harvard		Foster	
			PSNR / SSIM / SAM	Time	PSNR / SSIM / SAM	Time	PSNR / SSIM / SAM	Time
×2	Bicubic	-	40.762 / 0.9623 / 2.665	-	42.833 / 0.9711 / 2.023	-	55.155 / 0.9881 / 4.391	-
	GDRRN [28]	219k	41.667 / 0.9651 / 3.842	0.193	44.213 / 0.9775 / 2.278	0.132	53.527 / 0.9963 / 5.634	0.217
	3D-FCNN [21]	39k	43.154 / 0.9686 / 2.305	1.138	44.454 / 0.9778 / 1.894	0.858	60.242 / 0.9987 / 5.271	1.201
	EDSR [14]	1404k	43.869 / 0.9734 / 2.636	0.098	45.480 / 0.9824 / 1.921	0.040	57.371 / 0.9978 / 5.753	0.104
	SSPSR [27]	10515k	-	-	-	-	-	-
	SSRNet [32]	830k	44.991 / 0.9737 / 2.261	1.231	46.247 / 0.9825 / 1.884	1.051	58.852 / 0.9987 / 4.064	1.179
	MCNet [9]	1928k	45.102 / 0.9738 / 2.241	2.096	46.263 / 0.9827 / 1.883	2.061	58.878 / 0.9988 / 4.061	2.322
	SFCSR (ours)	1085k	45.300 / 0.9739 / 2.217	2.280	46.342 / 0.9830 / 1.880	2.017	58.859 / 0.9988 / 4.052	2.764

PSNR (Peak Signal-to-Noise Ratio) is used to assess the degree of similarity between the reconstructed image and the original image. **The higher the PSNR value, the smaller the difference between the reconstructed image and the original image**, and the higher the image quality.
SSIM (The Structural Similarity Index) is an index used to evaluate the similarity of two images, taking into account brightness, contrast and structure. **The SSIM value is between 0 and 1, and the closer the value is to 1, the more similar the two images are.**
SAM (Spectral Angle Mapper) is an index used to compare the similarity between two spectral vectors. SAM measures the Angle between two spectral vectors, and **the smaller the Angle, the more similar the two spectral vectors are**. In hyperspectral image processing, SAM is often used to evaluate the spectral accuracy and accuracy of reconstructed images.