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Toward Stable, Interpretable, and Lightweight Hyperspectral Super-resolution

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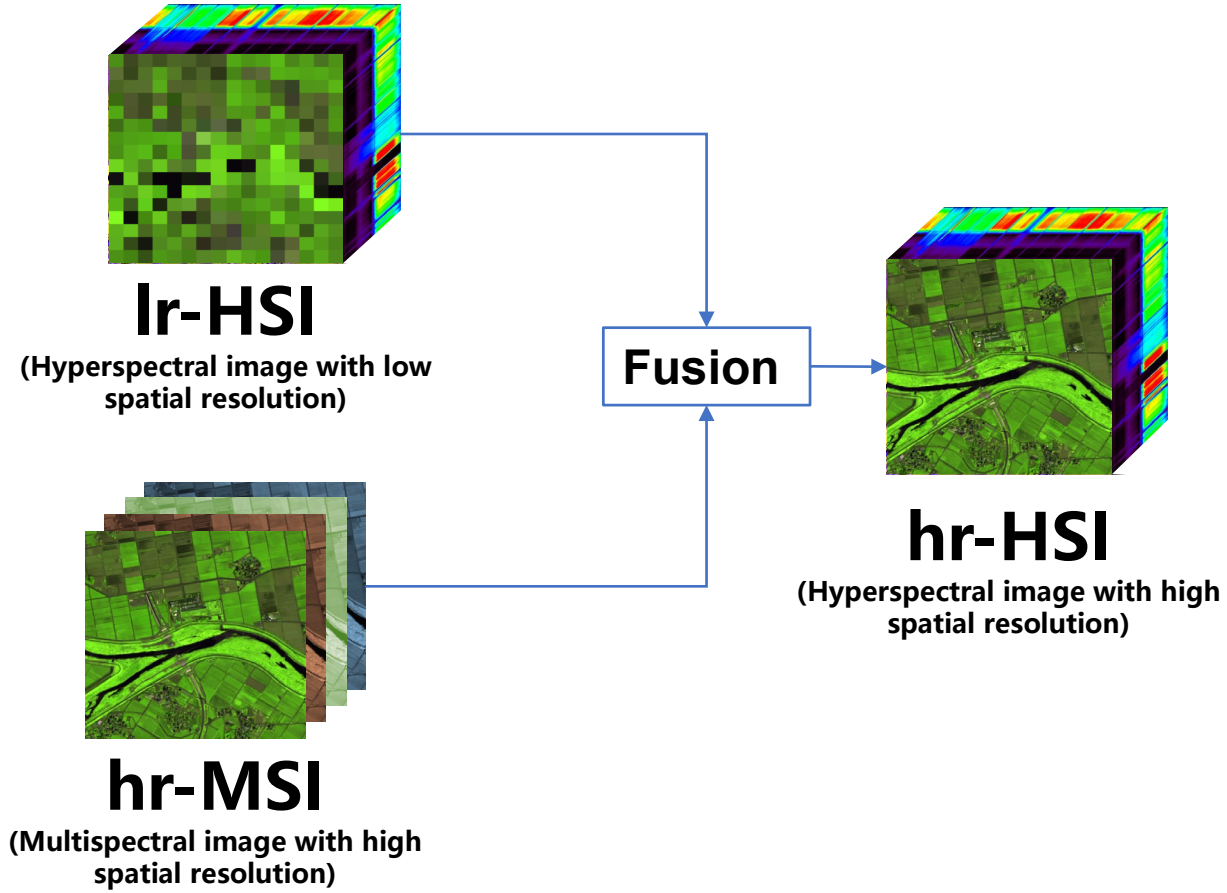
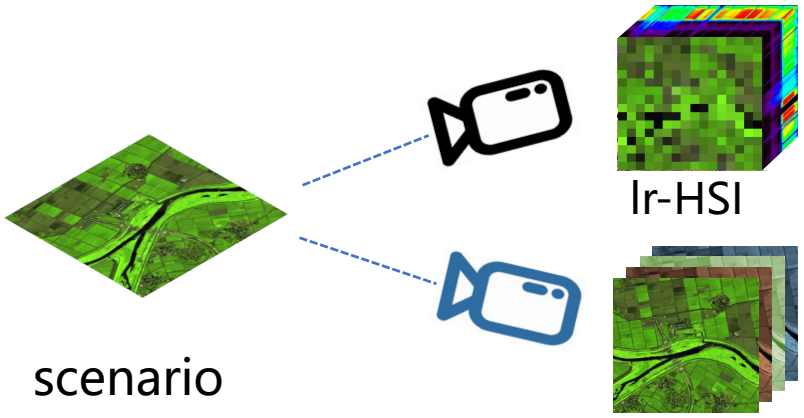
THU-PM-159

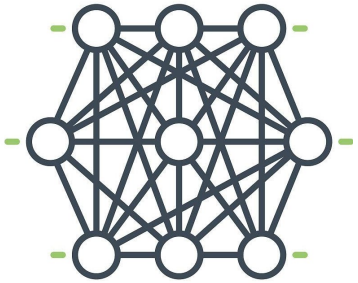
➢Hyperspectral image super-resolution(HSI-SR)

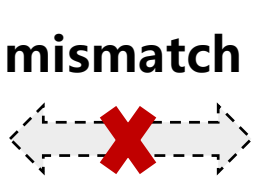


- Recover the ideal hr-HSI from hr-MSI and lr-HSI.
- Fuse the spatial information from lr-HSI and the spectral information from hr-MSI.

➢Challenges







Complex and dynamic degradation in imaging

Complicated network structures in previous works

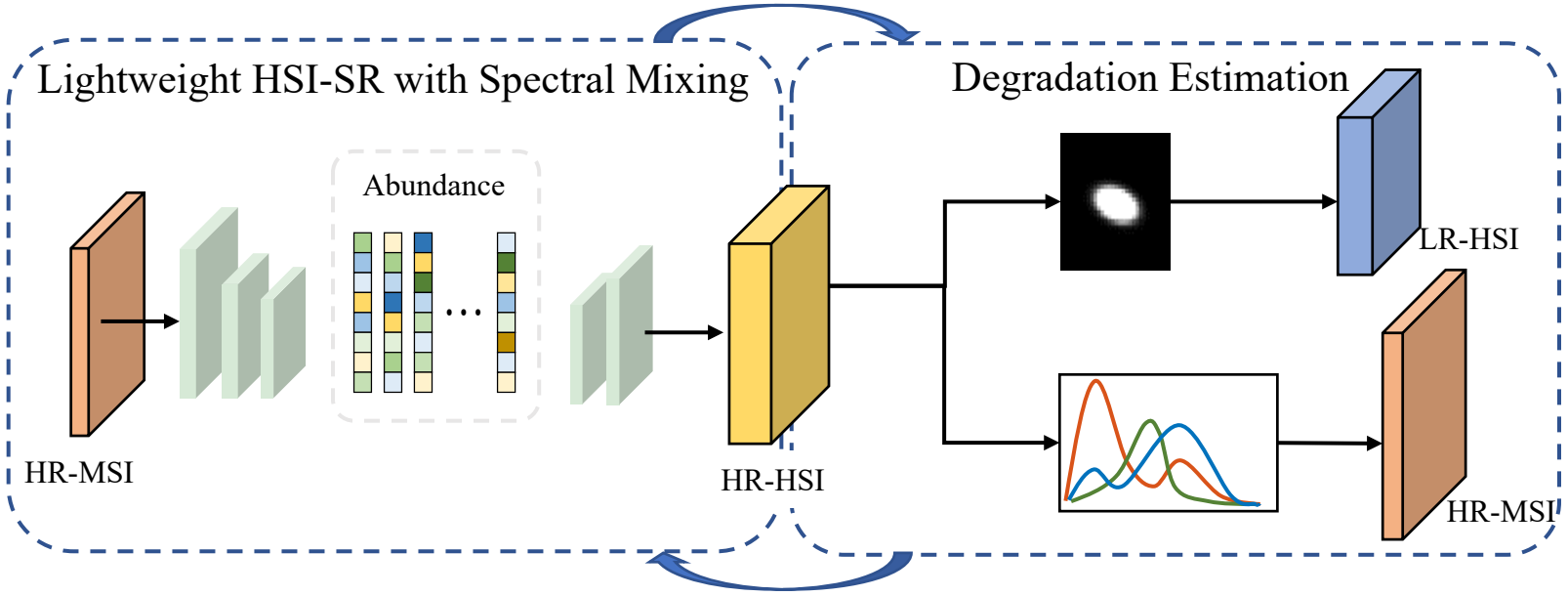
Limited computation resource on satellite

Urgent need for **stability**

Clear insight of network modules: **interpretability**

The necessity of **lightweight**

➢Main idea



Degradation-aware fusion:
The guidance of the estimated degradations shrinks the space of recovery, hence improving the **Stability**

Spectral mixing mechanism:
Through merging the physical prior in network design, approve **Interpretable** fusion

Single autoencoder:
Implement the unmixing mechanism through an autoencoder with only 5 convolution layers, realizing a **Lightweight** model

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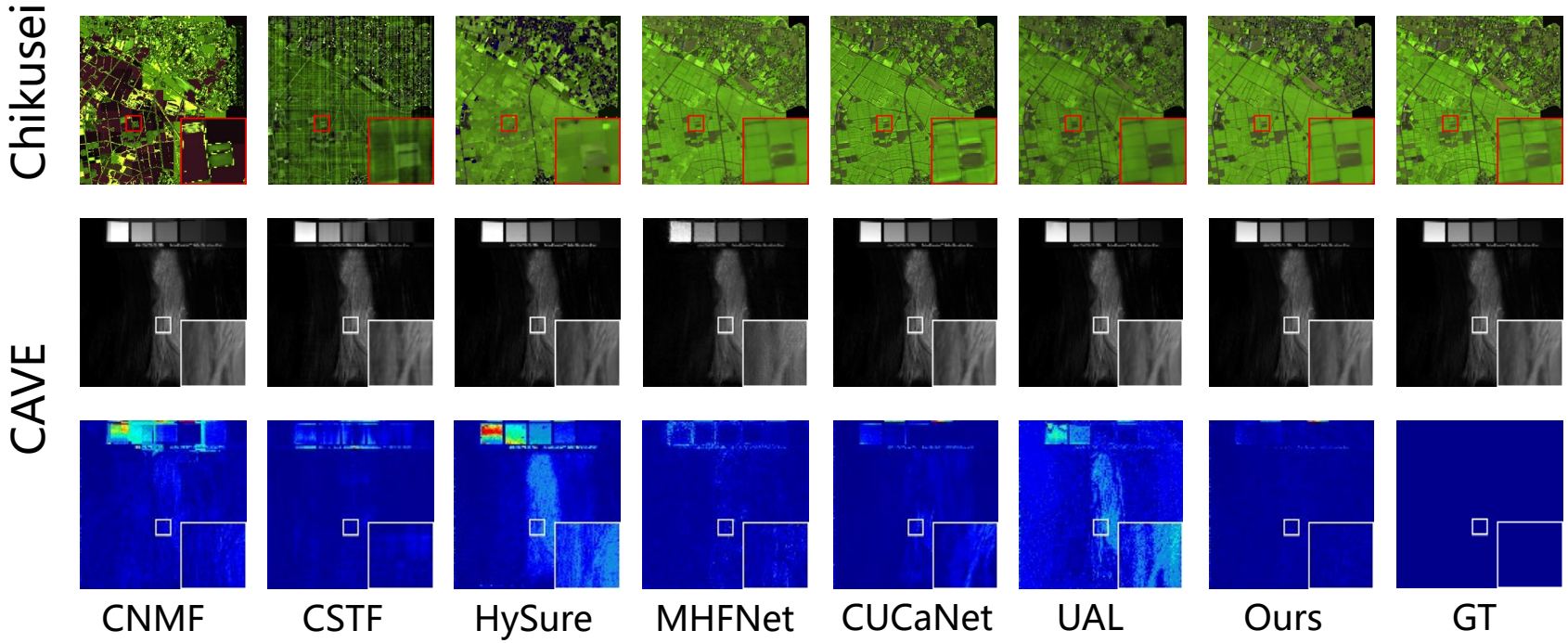
➢Results

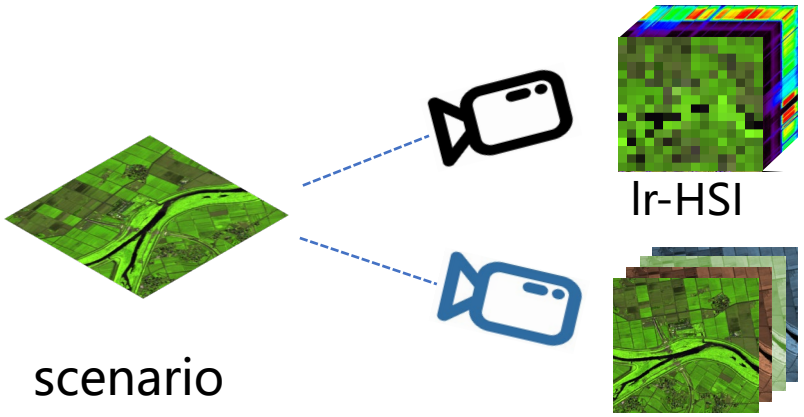
Datasets	CAVE				Harvard				Chikusei			
Methods	PSNR	SAM	ERGAS	UQI	PSNR	SAM	ERGAS	UQI	PSNR	SAM	ERGAS	UQI
CNMF	29.3	17.8	2.16	0.702	25.7	13.3	1.76	0.580	24.5	17.8	1.38	0.721
Hysure	28.0	24.1	1.27	0.789	35.2	7.01	0.652	0.908	21.8	10.3	2.67	0.644
CSTF	29.5	14.8	1.03	0.817	34.7	7.16	0.640	0.923	25.7	11.8	1.56	0.848
MHFNet	37.3	9.57	0.693	0.928	41.1	3.57	0.312	0.988	33.6	7.07	0.638	0.951
CUCaNet	34.3	13.6	0.964	0.963	37.3	6.10	1.42	0.936	27.3	5.82	0.753	0.890
UAL	37.2	9.83	0.785	0.912	40.7	7.11	0.824	0.964	28.9	7.55	1.249	0.888
Ours	**39.5**	**6.74**	**0.340**	**0.944**	**42.4**	**3.20**	**0.276**	**0.995**	**33.7**	**3.77**	**0.591**	**0.980**

Methods	FLOPs (G)	Param (M)	Training Time (min)	Testing Time (s)
CNMF	/	/	/	101.2
CSTF	/	/	/	123.8
HySure	/	/	/	153.8
MHFNet	21226	129.4	1255	23.95
CUCaNet	7226	2.28	/	34.2(min)
UAL	9275	27.05	351	29.7
Ours	**1.67**	**0.019**	**86.8**	**20.5**

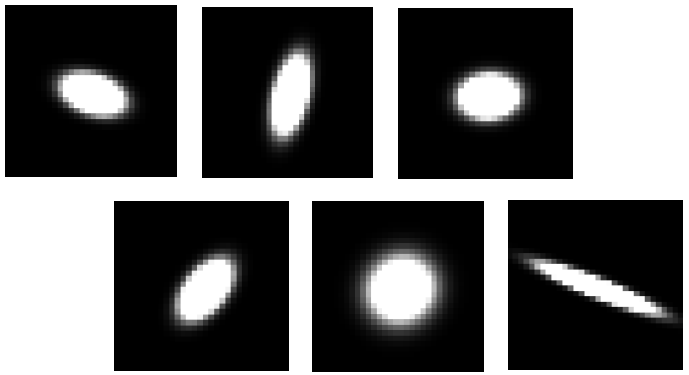


Our approach outperforms state-of-the-art by a large margin in **fidelity** and **efficiency**.

➢Main challenge: Stability



Dynamic degradations:



✗Utilize a fixed degradation parameter during training and test

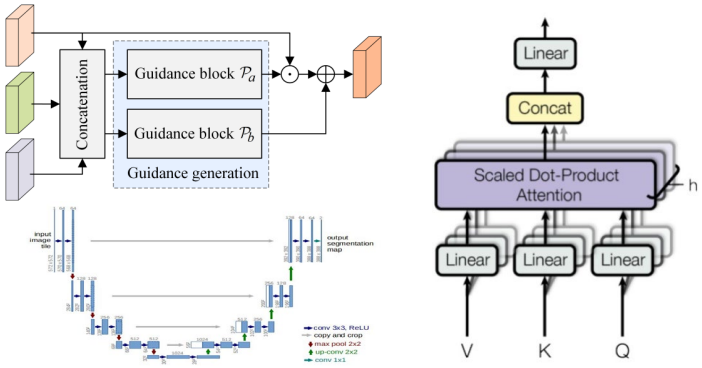
✗Apply the learned degradation parameters during testing

Previous methods

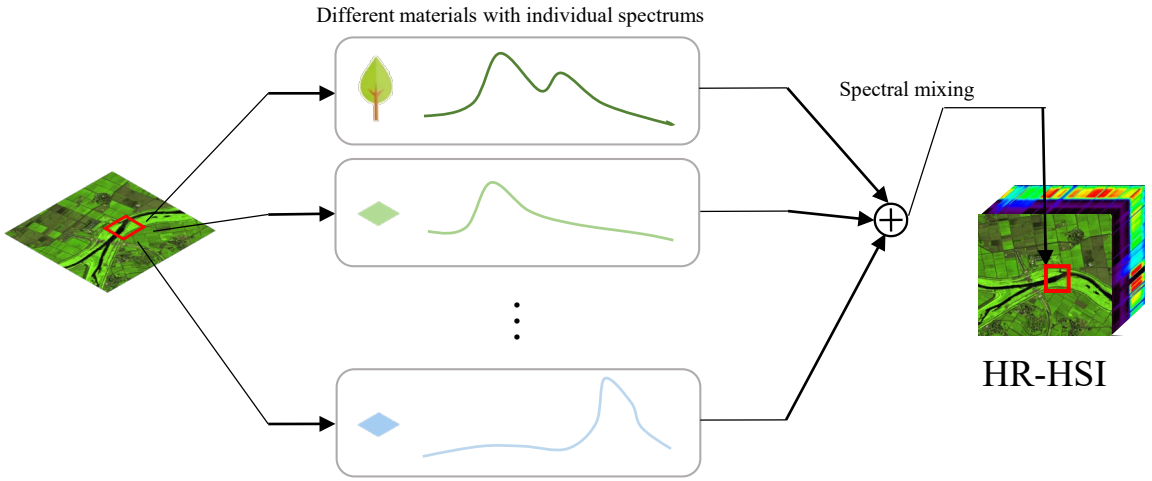
✓Learn degradations adaptively during both training and test

✓ Guide the fusion with learned degradation to reduce the solution space

➢Main challenge: Interpretability & Lightweight



Previous methods with complex networks



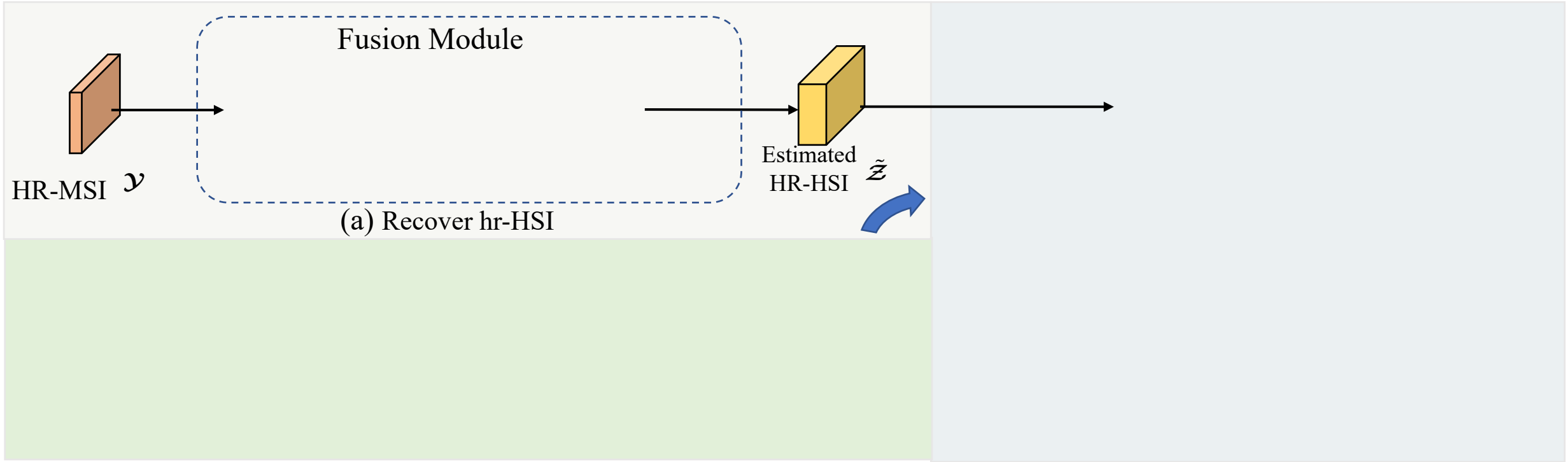
✗Treat HSI-SR as a black-box optimization, leading to poor **interpretability**

✗Complicated network architectures results in **high computation burden**

✓Simulate the inherent spectral mixing mechanism during fusion, bring **clear insight** in network structure

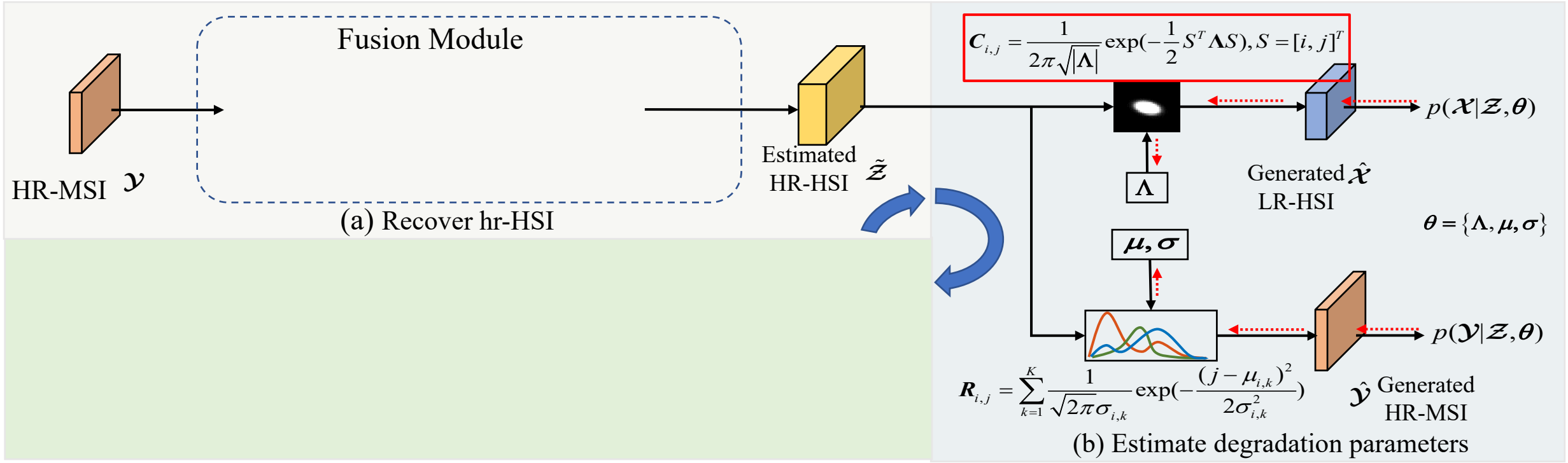
✓ With the guidance of physical prior, **simple** network can achieve **efficient** recovery

➢Main idea: Degradation-aware fusion



Establish a positive loop between fusion and degradation estimation

➢Main idea: Degradation-aware fusion



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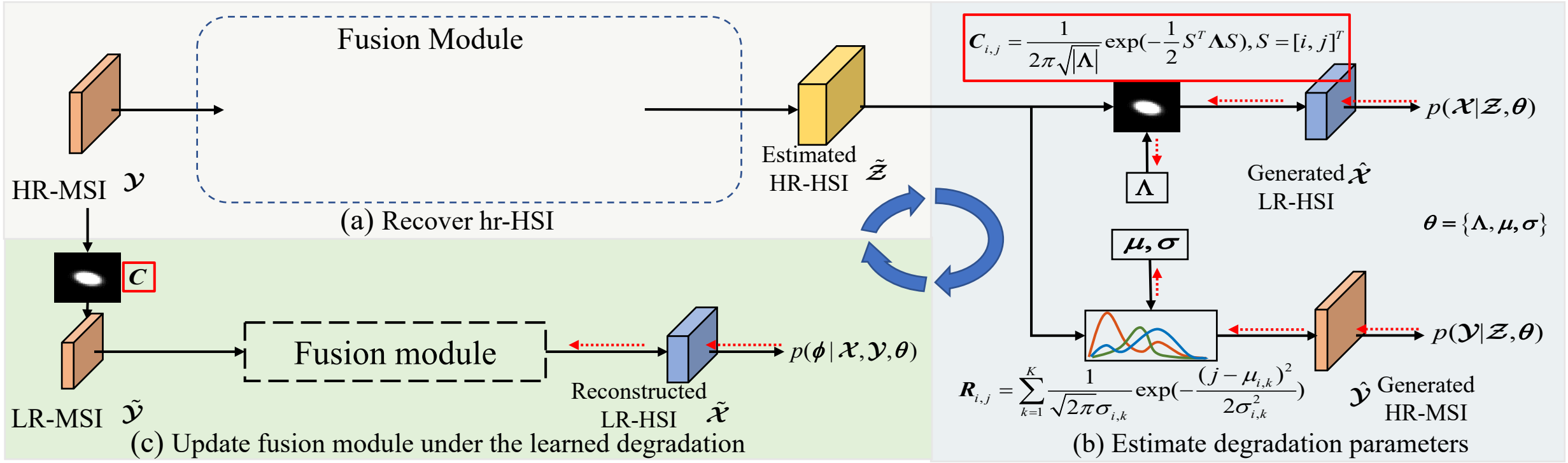
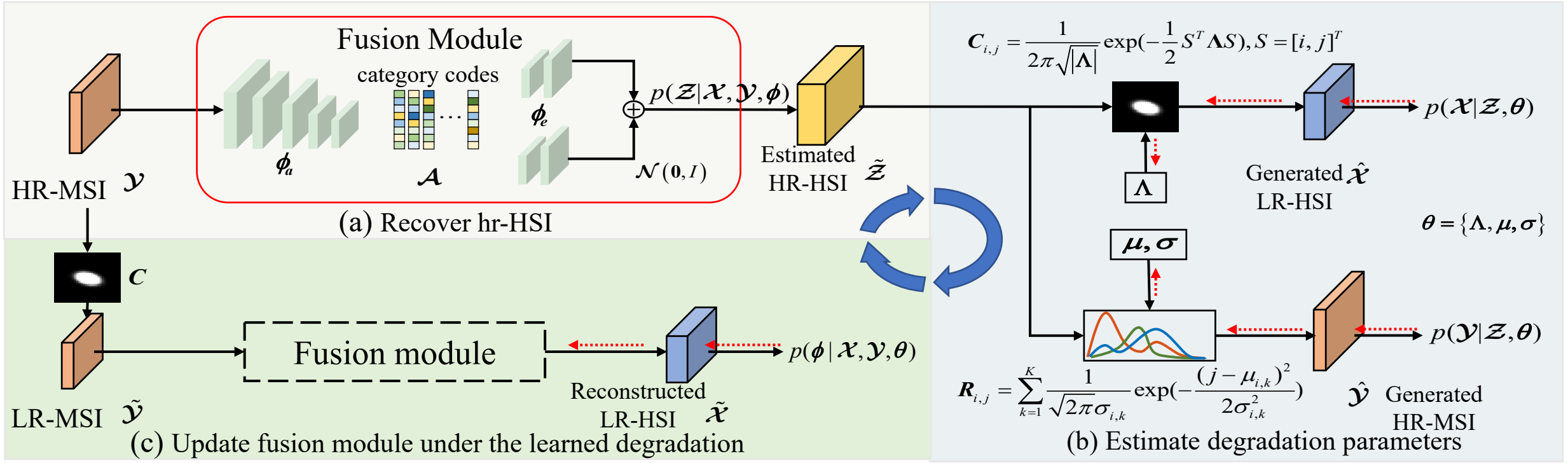


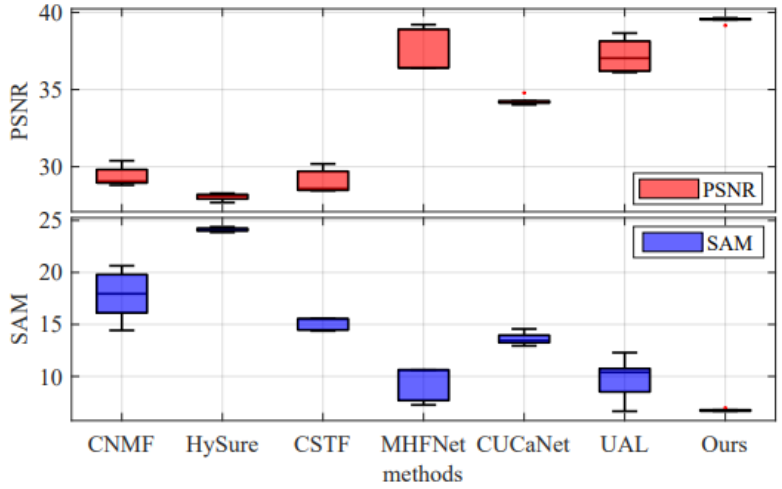
Establish a positive loop between fusion and degradation estimation

➢Main idea: Spectral mixing mechanism

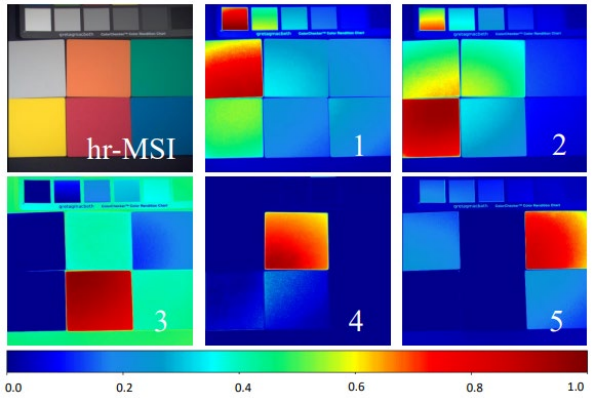


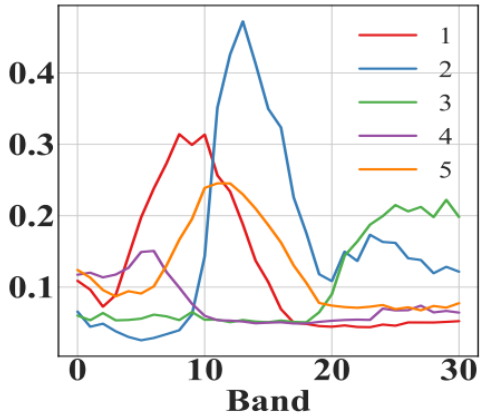
Utilize the inherent physical prior in HSIs and implement with a single autoencoder

➢Results

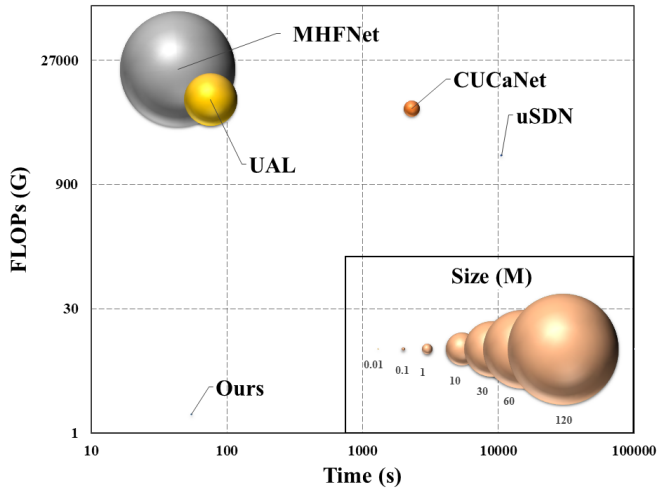


Our method is remarkably superior to other methods in stability





The fusion module in our methods simulates the spectral mixing mechanism precisely



Our method surpass other methods in scale, computation complexity, and time consumption with a large margin.