Unsupervised Lightweight 3D Convolutional Network for Enhanced Infrared Imaging in Wearable Devices

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Frontiers of Computer Science, DOI: 10.1007/s11704-025-40948-7

Problems & Ideas

- Problems of Enhanced Infrared Imaging in Wearable Devices:
  - Imaging performance challenges: imaging results suffer from lack of contrast, dark areas, high noise, and blurred edges;
  - Lack of high quality paired infrared images;
  - Low power consumption and sustainability requirements: lightweight model that can be integrated into a variety of embedded platforms.
- Ideas: Infrared image enhancement is conceptualized as generating high dynamic range infrared images from the corresponding temperature sequences during thermal equilibrium.

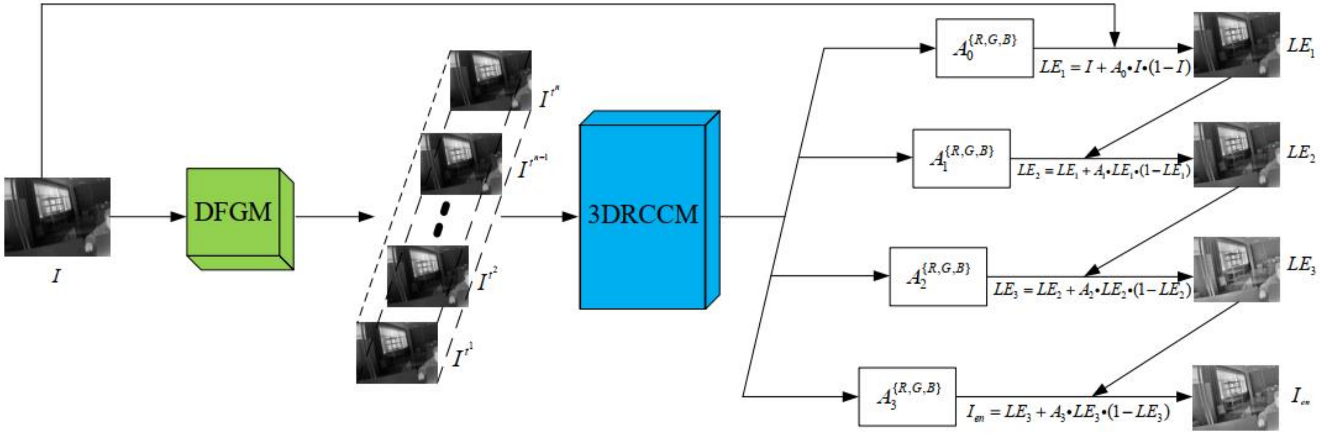

Fig.1 The overall framework of UL3DCN, which primarily consists of two key components: the Dynamic Filter Generation Module (DFGM) and the 3D Rubik's Cube Correlation Module (3DRCCM)

Main Contributions

- Contributions:
  - A novel unsupervised lightweight 3D convolutional neural network(UL3DCN) can effectively enhance imaging in wearable infrared imaging devices;
  - The Dynamic Filter Generation Module (DFGM) simulates infrared image sequences, effectively extending infrared image from the spatial to the spatio-temporal domain;
  - The 3D Rubik's Cube Correlation Module (3DRCCM), which accurately estimates the higher-order curves required for pixel-level adjustments and dynamic range enhancement of infrared images.

Table 1 Comparison experiments of related methods, with '_' sign representing none. '↓' indicates that the lower the value, the better the indicator, '↑' indicates that the higher the value, the better the indicator.

Category	Method	Year	MSE↓	PSRN(dB)↑	SSIM↑	BRISQUE↓	NIQE↓	Params(M)
	GHE [23]	_	0.210	12.312	0.633	32.356	10.463	_
	CLAHE [28]	1994	0.229	12.533	0.746	31.421	9.436	_
Traditional	BPDFHE [32]	2013	0.222	11.492	0.693	31.374	9.684	_
	DUAL [43]	2019	0.214	13.237	0.804	31.646	9.423	_
	MSR [44]	2014	0.262	11.364	0.260	37.179	11.563	_
	RetinexNet [40]	2018	0.131	17.449	0.866	31.752	10.794	2.12M
	IE-CGAN [36]	2018	0.107	19.014	0.871	30.862	9.316	0.32M
	DeepUPE [45]	2019	0.144	15.483	0.828	31.843	9.7231	2.28M
Deep Learning	IAT [46]	2022	0.153	16.415	0.891	31.584	9.694	0.42M
	Zero-DCE [19]	2020	_	_	_	31.137	9.422	0.63M
	SCI [47]	2022	0.103	19.699	0.943	32.316	9.488	0.43M
	SwinIR [48]	2022	0.126	18.294	0.863	31.471	9.867	98.1M
	Ours	2024	**0.087**	**22.283**	**0.964**	**30.669**	**9.284**	**1.23M**

Comparison of experimental results and indicators: left: enhanced infrared image; right: experimental comparison indicators