Towards Flexible Blind JPEG Artifacts Removal

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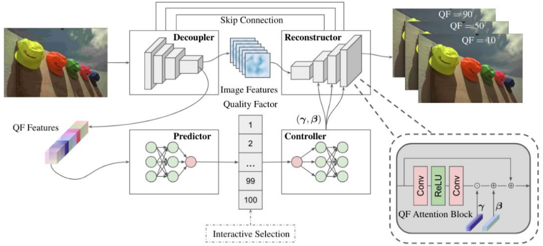
Motivations

JPEG is one of the most widely-used image compression algorithms and formats but can introduce annoying artifacts. Existing methods for JPEG artifacts removal generally have four limitations in real applications:

- Most existing learning-based methods trained a specific model for each quality factor.
- DCT-based methods need to obtain the DCT coefficients or quantization table as input, which is only stored in JPEG format. Besides, when images are compressed multiple times, only the most recent compression information is stored.
- Existing blind methods can only provide a deterministic reconstruction result for each input, ignoring the need for user preferences.
- Existing methods are all trained with synthetic images which assumes that the low-quality images are compressed only once. *However, most images from the Internet are compressed multiple times.*

Architecture of FBCNN



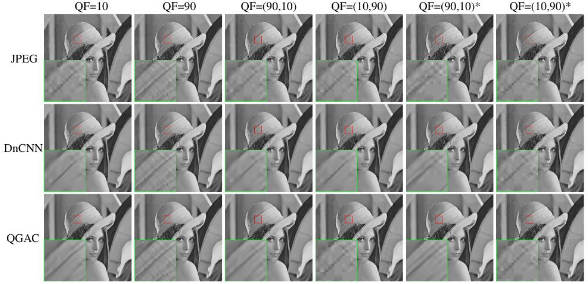
The decoupler extracts the deep features from the input corrupted JPEG image and then splits them into image features and QF features which are subsequently fed into the reconstructor and predictor, respectively. The controller gets the estimated QF from the predictor and then generates QF embeddings. The QF attention block enables the controller to make the reconstructor produce different results according to different QF embeddings. The predicted QF can be changed with interactive selections to control the balance between artifacts removal and details preservation.

Double JPEG Restoration

1. What is non-aligned double JPEG compression?

It means that the 8x8 blocks of two JPEG compression are not aligned. For example, when we crop a JPEG image and save it also as JPEG.

2. Limitations of existing blind methods



'*' means there is a one-pixel shift between two JPEG blocks.

3. Our solutions

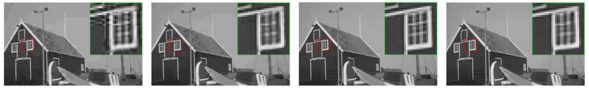
(1) FBCNN-D: Adjust predicted quality factor to the dominant smaller one.
(2) FBCNN-A: Augment the training data with double JPEG degradation model:

$$y = \mathrm{JPEG}(\mathrm{shift}(\mathrm{JPEG}(x, \mathrm{QF}_1)), \mathrm{QF}_2)$$

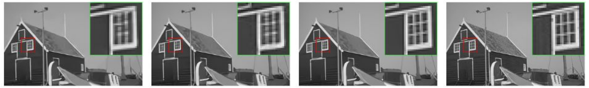
Experiments

1. Single JPEG restoration

Dataset	Quality	JPEG	ARCNN*	MWCNN*	DnCNN	DCSC	QGAC	FBCNN (Ours)
Classic5	10	27.82|0.760|25.21	29.03 |0.793|28.76	30.01|0.820|29.59	29.40|0.803|29.13	29.62|0.810|29.30	29.84|0.812|29.43	30.12|0.822|29.80
	20	30.12|0.834|27.50	31.15|0.852|30.59	32.16|0.870|31.52	31.63|0.861|31.19	31.81|0.864|31.34	31.98|0.869|31.37	32.31|0.872|31.74
	30	31.48|0.867|28.94	32.51|0.881|31.98	33.43|0.893|32.62	32.91|0.886|32.38	33.06|0.888|32.49	33.22|0.892|32.42	33.54|0.894|32.78
	40	32.43|0.885|29.92	33.32|0.895|32.79	34.27|0.906|33.35	33.77|0.900|33.23	33.87|0.902|33.30	34.05|0.905|33.12	34.35|0.907|33.48
LIVE1	10	27.77|0.773|25.33	28.96|0.808|28.68	29.69|0.825|29.32	29.19|0.812|28.90	29.34|0.818|29.01	29.51|0.825|29.13	29.75|0.827|29.40
	20	30.07|0.851|27.57	31.29|0.873|30.76	32.04|0.889|31.51	31.59|0.880|31.07	31.70|0.883|31.18	31.83|0.888|31.25	32.13|0.889|31.57
	30	31.41|0.885|28.92	32.67|0.904|32.14	33.45|0.915|32.80	32.98|0.909|32.34	33.07|0.911|32.43	33.20|0.914|32.47	33.54|0.916|32.83
	40	32.35|0.904|29.96	33.61|0.920|33.11	34.45|0.930|33.78	33.96|0.925|33.28	34.02|0.926|33.36	34.16|0.929|33.36	34.53|0.931|33.74
BSDS500	10	27.80|0.768|25.10	29.10|0.804|28.73	29.61|0.820|29.14	29.21|0.809|28.80	29.32|0.813|28.91	29.46|0.821|28.97	29.67|0.821|29.22
	20	30.05|0.849|27.22	31.28|0.870|30.55	31.92|0.885|31.15	31.53|0.878|30.79	31.63|0.880|30.92	31.73|0.884|30.93	32.00|0.885|31.19
	30	31.37|0.884|28.53	32.67|0.902|31.94	33.30|0.912|32.34	32.90|0.907|31.97	32.99|0.908|32.08	33.07|0.912|32.04	33.37|0.913|32.32
	40	32.30|0.903|29.49	33.55|0.918|32.78	34.27|0.928|33.19	33.85|0.923|32.80	33.92|0.924|32.92	34.01|0.927|32.81	34.33|0.928|33.10



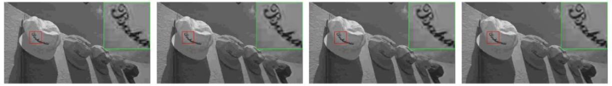
(a) JPEG (29.64dB) (b) ARCNN (31.15dB) (c) MWCNN (32.38dB) (d) DnCNN (31.36dB)



(e) DCSC (31.68dB) (f) QGAC (31.97dB) (g) FBCNN (32.51dB) (h) Ground Truth

2. Non-aligned double JPEG restoration

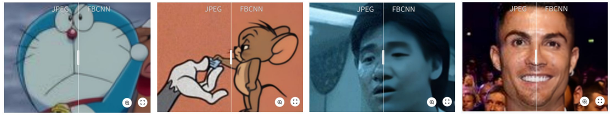
Type	QF	JPEG	DnCNN	DCSC	QGAC	FBCNN (Ours)	FBCNN-D (Ours)	FBCNN-A (Ours)
$QF_1>QF_2$	(30,10)	27.49|0.762|25.62	28.95|0.805|28.61	29.08|0.810|28.81	29.24|0.818|28.94	29.46|0.820|29.11	29.46|0.820|29.10	29.44|0.818|29.12
	(50,10)	27.65|0.769|25.69	29.13|0.810|28.76	29.25|0.815|28.96	29.42|0.823|29.08	29.64|0.825|29.23	29.65|0.825|29.22	29.61|0.823|29.20
	(50,30)	30.62|0.866|28.85	32.20|0.895|31.50	32.30|0.897|31.78	32.32|0.899|31.72	32.61|0.902|31.88	32.61|0.902|31.89	32.69|0.901|32.24
$QF_1=QF_2$	(10,10)	26.48|0.715|25.08	27.73|0.765|27.49	27.76|0.768|27.59	27.78|0.771|27.59	27.96|0.774|27.75	27.95|0.774|27.74	28.25|0.777|28.14
	(30,30)	29.98|0.847|28.53	31.40|0.878|30.86	31.48|0.880|31.10	31.43|0.881|30.99	31.64|0.884|31.14	31.65|0.884|31.14	31.94|0.886|31.73
	(50,50)	31.58|0.888|30.18	33.12|0.912|32.44	33.28|0.914|32.80	33.12|0.914|32.50	33.38|0.917|32.61	33.45|0.914|32.85	33.70|0.919|33.34
$QF_1<QF_2$	(10,30)	27.55|0.760|26.94	28.33|0.790|28.17	28.31|0.789|28.19	28.30|0.791|28.18	28.29|0.791|28.15	28.94|0.802|28.82	29.38|0.816|29.30
	(10,50)	27.69|0.768|27.41	28.30|0.791|28.24	28.40|0.794|28.35	28.23|0.791|28.18	28.20|0.789|28.14	28.96|0.801|28.88	29.52|0.820|29.45
	(30,50)	30.61|0.865|29.60	31.89|0.890|31.46	32.08|0.893|31.78	31.81|0.891|31.43	31.96|0.893|31.50	32.31|0.895|31.94	32.64|0.900|32.49



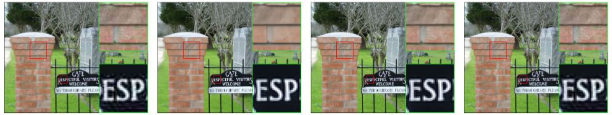
(a) JPEG (31.34dB) (b) DnCNN (32.10dB) (c) DCSC (31.97dB) (d) QGAC (32.06dB)

(e) FBCNN (32.04dB) (f) FBCNN-D (32.89dB) (g) FBCNN-A (33.62dB) (h) Ground Truth

3. Real-world JPEG restoration



4. Flexibility of FBCNN



(a) JPEG (27.45dB) (b) QF = 10 (28.13dB) (c) QF = 30 (29.34dB) (d) QF = 90 (28.05dB)

Conclusion

In this paper, we proposed a flexible blind JPEG artifacts removal network (FBCNN) for real JPEG image restoration. FBCNN can predict the quality factor and use it to guide image restoration. The predicted quality factor can also be adjusted to achieve a balance between artifacts removal and details preservation. Besides, we address non-aligned double JPEG restoration tasks to take steps towards real JPEG images with severe degradations. We achieve state-of-the-art results on on single JPEG images, the more general double JPEG images, and real-world JPEG images.