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Automatic image enhancement by learning adaptive patch selection

Key words: Image enhancement; Contrast enhancement; Dark channel; Bright channel; Adaptive patch based processing

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Motivation

1. Existing patch-based methods for image enhancement are essentially local histogram stretching. When enhancing a pixel with its neighborhood, we actually stretch the histogram of the local patch and pick up the enhanced value for the target pixel.
2. If the histogram is sharp, the stretching will fail. That is why we need a better approach for image enhancement.
3. With current methods, if better results are required, users must tune the patch size to achieve appropriate enhancement.

Main Idea

1. Double channels:

- (1) Dark and bright channel priors are combined to enhance a target pixel, which is essentially local linear histogram stretching;
- (2) Dealing with various exposure problems, for instance, being under-exposed, backlit, or foggy.

2. Adaptive patch selection:

- (1) Different target pixels require different patch sizes for channel computing;
- (2) The best patch-size for a given target pixel is determined by the contrast of the patch. Flat regions need large patches.

Algorithm pipeline

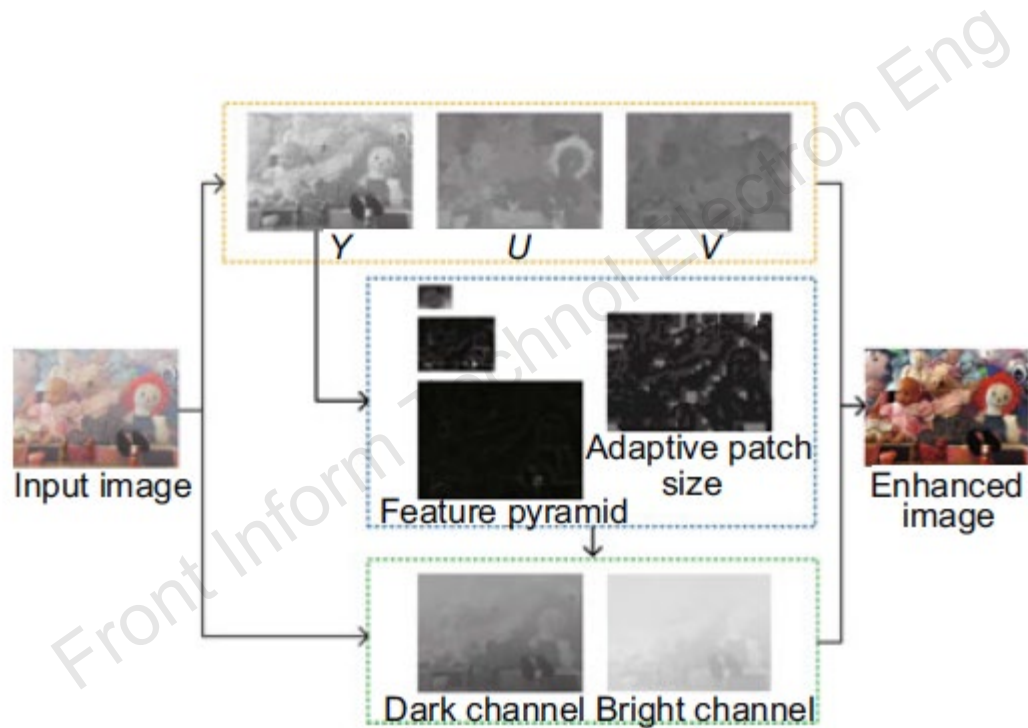


Fig. 4 Proposed automatic image enhancement pipeline

Double channels

Using double channels gives similar results to DCP and BCP, but in this case both foggy and underexposed/backlit images can be dealt with under a single schema.

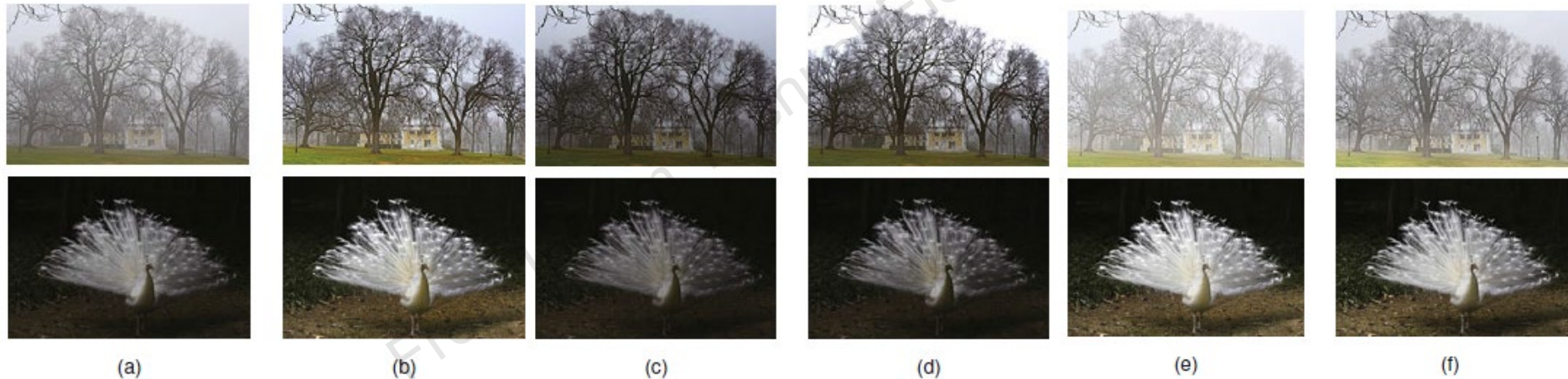


Fig. 2 Comparison between a single channel and double channels: (a) input image; (b) double channels; (c) dark channel only; (d) dark channel prior; (e) bright channel only; (f) bright channel prior

Best-fit local patch

With the adaptive patch size, the algorithm can enhance images in various conditions, while requiring parameter tuning.

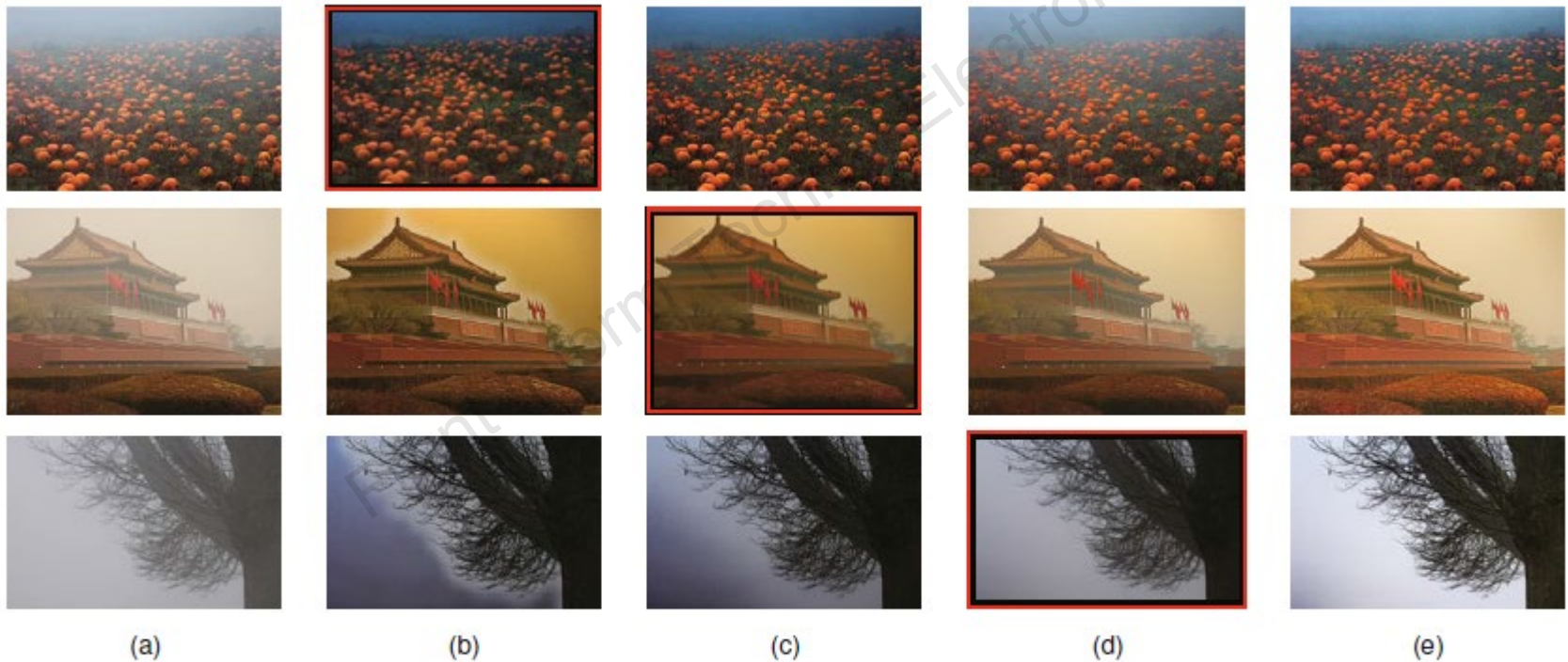


Fig. 3 Comparison between fixed and adaptive patches where dark channel prior with different patch sizes for dark channel (DC) and guided filter (GF) in (b)–(d): (a) input image; (b) DC/GF:15; (c) DC:15, GF:71; (d) DC/GF:141; (e) our result. References to color refer to the online version of this figure

Major results

Table 5 Metrics on foggy test images

Method	μV	μS	AIC	CII	UR
Origin	138.26	0.1660	7.053	1.000	2.196
DCP	113.67	0.3280	6.909	3.182	2.804
BCP	169.89	0.1684	7.092	1.402	2.283
LHSG	142.15	0.1882	7.304	2.069	3.500
DCAP	145.54	0.3273	7.486	2.603	3.696

Bold numbers denote the best results

Table 6 Metrics on under-exposed test images

Method	μV	μS	AIC	CII	UR
Origin	46.30	0.3623	5.977	1.000	1.957
DCP	45.78	0.4097	5.927	1.291	1.739
BCP	79.63	0.4139	6.603	3.072	2.783
LHSG	84.80	0.4177	6.215	5.002	3.391
DCAP	85.96	0.4494	7.030	4.811	3.304

Bold numbers denote the best results

Table 7 Metrics on backlit test images

Method	μV	μS	AIC	CII	UR
Origin	98.79	0.2369	6.822	1.000	2.250
DCP	96.42	0.3307	6.384	1.820	1.708
BCP	128.75	0.2547	6.864	2.153	2.958
LHSG	107.83	0.2293	6.808	1.504	2.333
DCAP	118.25	0.3383	7.283	2.996	3.250

Bold numbers denote the best results

DCP: dark channel prior

BCP: bright channel prior

LHSG: local histogram stretching globally

DCAP: double channels with adaptive patches

μV : mean intensity

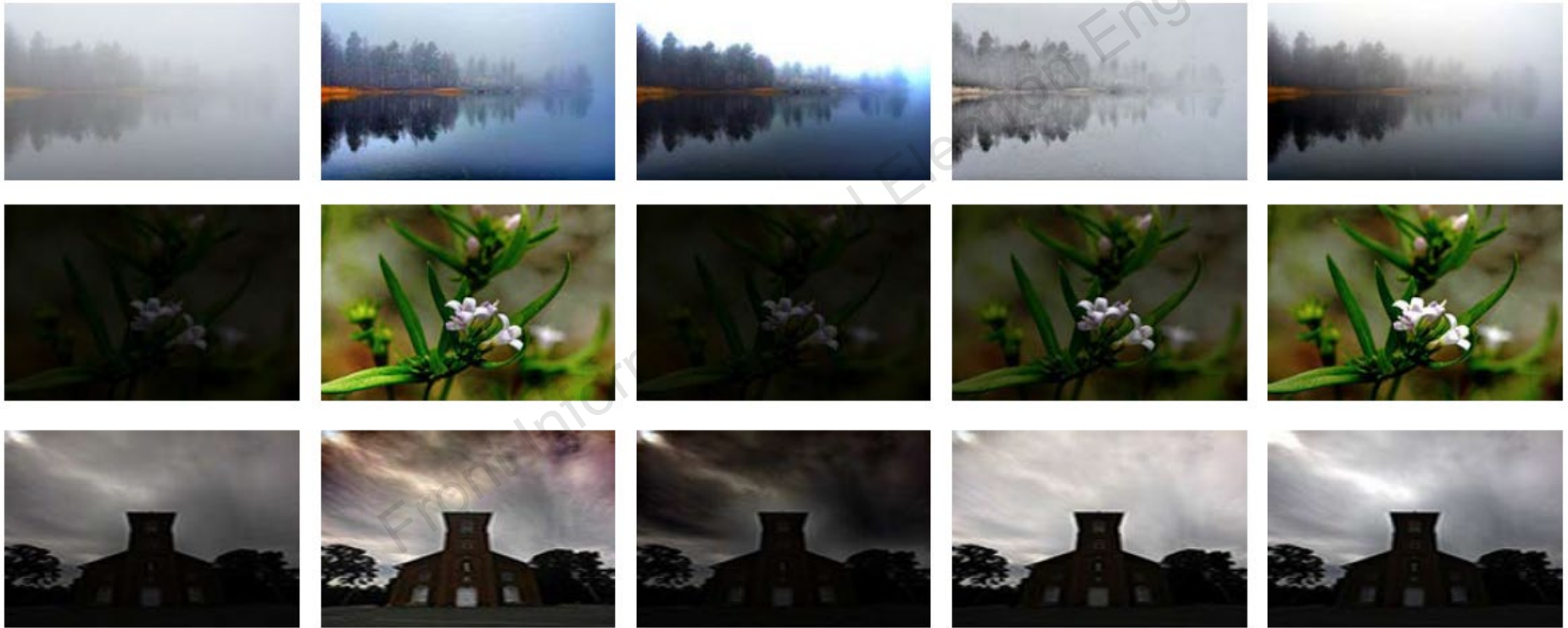
μS : mean saturation

AIC: average information content

CII: contrast improvement index

UR: user rating

Major results



(a) Input image

(b) DCAP

(c) DCP

(d) BCP

(e) LHSG

Conclusions

1. An automatic image enhancement method using double channels and adaptive patch size has been proposed.
2. Since all the parameters in our algorithm are trained from a data set, the algorithm is totally automatic.
3. The drawback of the proposed algorithm is that it is comparatively time consuming, which can be optimized by engineering methods to some extent.